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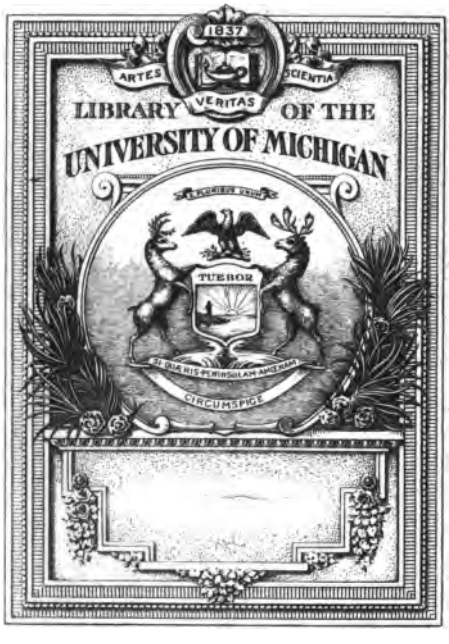
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Incorporated gas institute.
Transactions

British Association of Gas Managers.

REPORT OF PROCEEDINGS

OF THE

TENTH ANNUAL MEETING,

HELD

AT THE QUEEN STREET HALL,

EDINBURGH.

JUNE, 1873.

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BRITISH

ASSOCIATION OF GAS MANAGERS.

REPORT OF PROCEEDINGS,

&c., &c.

The Tenth Annual General Meeting of this Association was held on Tuesday, Wednesday, and Thursday, the 10th, 11th, and 12th of June, at the Queen Street Hall, in the City of Edinburgh.

TUESDAY, JUNE 10.

The PRESIDENT, A. Angus Croll, Esq., A.I.C.E., took the chair at eleven o'clock.

The minutes of the last general meeting, and the statement of accounts for the past year, which had been previously printed and circulated among the members, were taken as read, and adopted.

The SECRETARY (Mr. W. H. Bennett) read the list of applications for membership, as follows:—

ORDINARY MEMBERS.

Alsop, S.	Pinxton, near Alfreton.
Anderson, J . . .	Ceará, Brazil.
Armitage, C. . . .	Darlington.
Bailey, G. D. . . .	London.
Bartley, C. L. . .	Blackburn.
Broadhead, J. . .	Grimsby.
Brown, C.. . . .	Wells, Somerset.
Carter, T.	London.
Coles, H. A. . . .	Todmorden.
Church, Jabez, jun. .	Westminster.
Darwin, C. B. . .	Maryport.
Douglas, D. . . .	Chesterfield.
Dover, J. W. . . .	Princes Risborough.
Drimmie, G. . . .	Holywood.
Earle, N.	Dover.
Earnshaw, J.. . .	Ashton-under-Lyne.
Edwards, A. J. . .	Taunton.
Ferguson, W.. . .	London.
Folosa, P. . . .	Mayaguiz, Porto Rico.
Forbes, J. J. . . .	Denby Dale.
Fuller, T. C. . . .	Ramsgate.
Furnivall, G. S. . .	Bradley Green.
Graham, D. A. . .	Stalybridge.
Greenaway, J. . .	Egham.
Guyatt, T. . . .	London.
Hamer, T. . . .	Chorley.
Hammond, J. . .	Bognor.
Hardy, W. . . .	Ely.
Harkewitz, H. . .	South Bank, Yorks.

Harrison, J. P. . .	Topsham.
Hart, W.	Wakefield.
Hatch, H.	Woolton.
Hathaway, H. . .	North Shields.
Hickling, L. . . .	Calcutta.
Hill, J. H.	Huyton.
Holmes, T. . . .	Pernambuco.
Howell, E	Yeovil.
Key, W.	Dumbarton.
Kimperley, J. . .	Normanton.
Lawton, R. . . .	Macclesfield.
Livesey, F. . . .	London.
McCrae, B. M. . .	Dundee.
McPherson, A. . .	Kirkcaldy.
Mead, A.	Chelmsford.
Mildred, M. . . .	London.
Parks, T.	Bristol.
Pazzani, J. . . .	Vienna.
Phillips, E. E. : .	High Wycombe.
Pritchard, F. . . .	St. Helens.
Reid, J.	Edinburgh.
Richards, W. . . .	London.
Riley, J.	Brighouse.
Salisbury, E H. . .	London.
Steinacher, J. E.. .	St. John's, Porto Rico.
Stevenson, G. E . .	Aberdare.
Stevenson, J. S. . .	Dublin.
Tayler, J..	Fareham.
Taylor, J.. . . .	Oldham.
Thomas, A. . . .	Alton.
Thomas, R. P. . .	Ware.
Waters, G. R.. . .	Portland.
Wilkinson, T. . .	Drighlington.

It was unanimously resolved—"That the gentlemen whose names have now been read be elected ordinary members of the association."

The SECRETARY read the names of the following gentlemen who had applied to be admitted extra-ordinary members of the association :—

EXTRA-ORDINARY MEMBERS.

Ashmore, W. . . .	Hope Iron-Works, Stockton-on-Tees.
Cowan, W. . . .	Buccleuch Street Works, Edinburgh.
Thorns, A. . . .	Farnley, near Leeds.
Vickary, C. J. . .	Exeter.

These gentlemen were unanimously elected extra-ordinary members.

Messrs. Brown and Frith were appointed scrutineers of the votes for the election of committee and officers for the ensuing year.

The PRESIDENT then delivered the following

INAUGURAL ADDRESS.

Gentlemen,—The growing interest which is being taken by the members of the association in its proceedings and objects cannot but afford a lively satisfaction to all of us, and the more so when it is considered that, in proportion as the general body of gas engineers in the kingdom unitedly combine as a compact and harmonious organization, not only will their professional interests be increasingly promoted and protected, but the public at large will the more readily recognize and respect the usefulness of the association.

The association was started in 1863, the preliminary meeting being held in December of that year, when about 40 gentlemen were enrolled as members. Last year we added to our list 63 ordinary and 8 extraordinary members, making the total number 425. To day we have an increase to our ranks of ordinary and extraordinary members, so that in this, the tenth year of our existence, we have acquired something like 489 members, a number which, considering the short time the society has been established, and the comparatively limited

class from which it is composed, cannot fail to be looked upon as an eminent success, and one well worthy of the promoters. Financially too we are progressing very satisfactorily. For the first year or two after the association commenced its operations it was scarcely able to meet its liabilities, but now, I am happy to say, after incurring a heavier expenditure last year than in any preceding one, we had a surplus of receipts over expenses of nearly £80, and have a balance of upwards of £390, part of which has, by desire of the committee, been invested in good securities. This state of things is a matter for sincere congratulation, the prosperity of an association being a fair index of the estimation in which it is held.

But while we are looking down our list, and congratulating ourselves upon the increase of our numbers, we cannot fail to see that some have been taken from us since our last meeting.

Amongst the deaths that have occurred since then are those of Mr. Green, of Heckmondwike; Mr. Jenkin, of Southampton; and Mr. Thomas Greaves Barlow. The latter was well known to you all as an honorary member and past president of this association. Mr. Barlow was born in 1811, and after receiving an ordinary education entered the office of his father, and was subsequently admitted as a partner in the firm of John Barlow and Sons, who were engaged in designing and erecting gas-works. In this way he was occupied for a number of years, in the course of which many extensive works both at home and abroad were erected under his supervision. Finding that the gas interest was becoming a most important one, and that there was no publication through which information was disseminated of special interest to the profession, although a periodical started for that purpose in 1847 had failed, he, in 1849, established the JOURNAL OF GAS LIGHTING, which continues, with but little or no alteration, to the present day. In its conduct he endeavoured to maintain a strictly independent course, and although exception was sometimes taken to the policy he pursued, I am persuaded that he most conscientiously believed in the views he supported.

He was decidedly of a conservative tendency, at the same time he was well aware that a liberal and conciliatory system on the part of gas companies as towards the public was the wisest policy, and was ever ready to advocate such a course. Latterly Mr. Barlow had devoted but little attention to the construction of works, being chiefly engaged in the settlement of disputes, in the valuation of gas undertakings, and in giving evidence before parliamentary and judicial tribunals. This association is considerably indebted to him for the support he gave it, and for his generosity in furnishing copies of the proceedings gratuitously at a time when the association could ill afford such an expense as the printing of their own transactions would entail. Mr. Barlow had not enjoyed robust health for some years, and for the last 12 or 18 months it had very much declined. He died in September of last year, leaving a vacancy in the gas world that will not be readily filled up.

These remarks regarding Mr. Barlow have been supplied by Mr. Bennett, he having perhaps a longer and closer connexion with our deceased friend than any other member of this association.

I may, however, state that, as far as I recollect, the first gas journal was commenced by Mr. Peckston, and the present one by Mr. George Barlow, uncle of our late friend.

At no former period in the history of gas enterprise have the value and importance of such an association as ours been more apparent. The delicacy, the difficulty, and the complicated nature of the duties which devolve upon the managers are such as to render meetings for mutual counsel and conference especially valuable. Day by day questions arise which concern the whole body of gas producers throughout the kingdom—questions in which the experience of one may be helpful for the guidance of all. The gas engineer of the present day must possess a practical familiarity with the chemical, mechanical, and mathematical sciences. And if professions which require only a comparatively limited range of knowledge meet for the exchange of views and the communication of information, surely we may well do so, who require for the efficient discharge of our duties an acquaintance with sciences so extensive and varied.

Nor is a mere scientific training sufficient for gas engineers.

As managers and employers of a large amount of skilled and unskilled labour, they are necessarily obliged to exercise much discretion and considera-

tion in their relation to the working classes; whilst their business connexions with capitalists, directors, shareholders, and gas consumers bring them into constant communication with many of the most influential and intelligent members of the community. Hence their position is one of much responsibility and importance in its social as well as its professional bearings. And never in the history of gas companies has the weight of the influence of our profession been so clearly manifested to the public as during the disturbed relations between labour and capital which have during the past 12 months so greatly interfered with every branch of national industry, and so directly affected the convenience and interests of gas producers and consumers in particular.

The sudden and extensive combination which, for a short time at least, threatened to plunge the whole of the metropolis in darkness, and which, in fact, occasioned much temporary inconvenience over a large area, forced upon the public in a very effectual and literally *striking* manner some appreciation of the value of the services hitherto rendered by our profession. And whilst there was felt a universal and just annoyance at the unreasonable and illegal action of those workmen who, to their own ultimate suffering and that of their families, yielded themselves as slaves to the domination of a few unscrupulous and blindly selfish agitators, those events clearly revealed to the public, to an extent never witnessed before, their large measure of indebtedness to the gas companies and their managers.

No words of mine can express too strongly the consternation caused by the prospect of London being left in darkness. For the first time the value and importance of the services rendered by our gas companies to the peace, security, and good order of society, were adequately recognized. If the attempt to suspend the production of gas had been successful, many most important industries would have been crippled or altogether arrested. The police of the metropolis would have been paralyzed—life and property would have been at the mercy of the dangerous classes. A sense of the perils escaped afforded to the public at large, for the first time, a measure of the services rendered.

The admirable manner in which the great difficulties of so sudden and grave an emergency were met and overcome by all the metropolitan companies, proved in the most conclusive manner the high character both of the professional and administrative talent which characterized their management; whilst the fidelity of a large number of the workmen (in spite of the utmost persuasions of the interested ringleaders of illegal agitation), and the eager desire of unemployed mechanics to fill the places rendered vacant by the strike, as plainly showed that the companies had treated their servants with a liberality and just consideration which commended itself to their practical appreciation and to that of the working classes generally.

At the same time the united verdict of the public and of the press ranged itself in favour of the just and able administration of the gas companies, especially as to their relations to those in their employ. Altogether, the body of gas managers can hardly expect ever to witness a more decisive and satisfactory testimony to their merits and abilities than that incidentally occasioned by the circumstances of the past year.

But we must not flatter ourselves that the danger is altogether at an end. The relations between labour and capital, between employer and employed, are far from being finally settled; and an emergency may yet arise which will tax to the utmost the individual and collective wisdom of the British Association of Gas Managers to prevent serious consequences to themselves or the public at large.

In reference to the general subject of the improvements in the manufacture and distribution of gas, I need hardly observe that to enter into details as to those improvements throughout the period which has elapsed during and since my own connexion with the profession would occupy too much of your time. I may, to illustrate, however, what may be done in this direction, briefly mention that when I was first appointed to the charge of the Chartered Gas Company's works at Brick Lane the price of gas was 9s. per 1000 feet, and at that time no attempt at purification was made beyond the use of wet lime and the most ordinary condensation. The gas was so surcharged with ammonia that it was sometimes observed that the worm upon the axis of the drum of the meter and the wheel acting upon it were destroyed with three months work; and, although the meters then in use would, in the case of the 8-light meter,

permit a registration of 22 per cent. against the consumer, and of only 15 as against the supplier, yet such was the destruction of the meters that the gas unaccounted for exceeded 20 per cent. The fuel account varied from 50 to 53 per cent. of the coke produced. The retorts were of the 12-inch iron D description, and 7 feet 6 inches in length.

By continued efforts during five years to remedy these defects I had the satisfaction, before leaving the company's service, of reducing the fuel account down to from 15 to 17 per cent., whilst the purification was so much improved as to result in a large diminution of the amount of gas unaccounted for. At the same time the profits of the shareholders had greatly increased.

It may also, perhaps, not be inappropriate to make some allusion on this occasion to the success which attended the formation of the Great Central Gas Company and the establishment of the Surrey Consumers Gas Company, and I may be pardoned for recurring with some degree of pride to the accomplishment of these works under difficulties which appeared almost insurmountable. For example, as is well known, in the case of the Great Central Company alone, the legal obstacles of every kind placed by its antagonists in the way of its obtaining parliamentary incorporation entailed a cost of £29,000. Not merely parliamentary, but municipal, parochial, and even physical impediments of every description were accumulated to hinder its progress. Nevertheless, all the objects of its projectors were ultimately secured; and within three months from the commencement of laying down the mains this work was carried out over 60 miles of streets, sometimes as many as 20 gangs of pipe-layers working simultaneously in as many localities. The whole of Upper and Lower Thames Street, from Blackfriars Bridge to the Tower of London—a distance of about a mile—was thus laid in one night. The mains were of such dimensions that within a leading one (of 26 inches internal diameter) two men proceeded throughout its length, from the gas-works to the City (3½ miles), for the purpose of paying out a telegraph wire, by which constant communication was secured between the works and the City, being the first application, it is believed, of the science of telegraphy to private purposes.

There is, however, no need for hesitation in recalling your attention to the important results, both to the advantage of the general public and to gas manufacturers, which ensued from the parliamentary investigations, the evidence given, and the demonstration of practical improvements connected with the establishment and early progress of the Great Central Company. The facts and figures then placed on record before the parliamentary committee on the bill for the incorporation of that company have, in the words of one of the directors of that company, "formed the basis of all subsequent gas reforms, and have been the means of giving, not only to London, but to all the large towns of the empire, a pure and cheap supply of gas, thereby conferring sanitary and commercial benefits upon all gas consumers." The same gentleman has also written of the Great Central Company, in a letter published two years ago, "This undertaking was not merely a commercial success, but demonstrated that simultaneously the consumer could receive a cheap and pure supply of gas, and the capitalist the largest return for his investment permitted by law" (10 per cent.); and as the following words are not my own, but his, they need not necessarily be omitted. He was pleased to add: "To Mr. Croll the public are indebted for the protection afforded by the appointment of a public officer to test the purity and illuminating power of the gas supplied, as well as the accuracy of the meters used by the consumer in its measurement. This protective power on behalf of the public has been incorporated in all subsequent Acts of Parliament relating to gas companies."

Circumstances connected with the history of the other company to which I have alluded (the Surrey Consumers Gas Company) led, but at a large private cost to myself, to the districting and the resulting combination of the various metropolitan companies—a movement whereby great advantages have accrued to gas interests both in London and the provinces.

The improvements which have taken place in gas property will be better understood when it is considered that at the time when I entered the service of the Chartered Gas Company the average dividend paid by all the companies did not much exceed 6 per cent., whilst it is now the highest allowed by Act of Parliament. And the marketable share value of the various companies may be taken at double what it then was.

Gentlemen, it has been asked, "What are the general objects of this association?" It may be replied that that object undoubtedly consists in the more efficient service of the public, involving as it does the interests alike of the gas producer and the gas consumer. These two are inseparably connected. The public cannot be efficiently served unless the producer is working profitably to himself. An industry which is not adequately remunerated, an investment which does not produce a profit fairly proportioned to the risk and responsibilities of the enterprise, is always conducted in an unsatisfactory manner. It is, therefore, to the interest of the consumer that the producer should derive a fair profit for his labour. And bearing in mind the risks and responsibilities of gas production, the periods over which the manufacture often runs before an adequate return is secured, and various other considerations which will suggest themselves to your own minds, it cannot be said that the parliamentary maximum of 10 per cent. is excessive.

But then, on the other hand, it must be borne in mind that it is at once our duty and our interest to study the interests of the consumer.

Our industry is of necessity a monopoly. We have entrusted to us the sole right of lighting a given area. Rights are conceded to us which, in the nature of the case, drive rivals from the field. These exclusive rights bring with them corresponding duties, and we are not to enjoy the one without caring for the other. And it is our interest as well as our duty to do this.

A monopoly may seem to override the common laws which regulate profit and loss in commercial transactions. But in the long run the principles of political economy prevail, and he who has had a monopoly conceded to him will find that he will work his monopoly most profitably by working it on the same principles as secure success to the manufacturer in the open market. If we attempt to take an unfair advantage of the public, we shall find that our profits are lessened rather than increased. Diminished consumption will follow an excessive price; inferior illuminating power will give occasion for the use of other methods of lighting. Impure gas will lead consumers to employ less injurious substitutes, and the right of monopoly abused will only punish the monopolists; whilst the fair and legitimate working of it would secure advantages to all parties. Hence it appears to me these our meetings ought to be specially occupied in discussing the best means of increasing the accommodation of the public, so far as the supply of gas is concerned. And it should be our study, in the first place, to furnish this in the most convenient manner; secondly, to render it of the greatest possible chemical purity; thirdly, of a high illuminating power; and lastly, at the lowest price consistent with a fair and reasonable dividend to the shareholders.

On each of these points I will offer a few remarks.

First, as to the general principle of seeking to accommodate the public as far as can be done. This principle should be kept prominently in view on various grounds, as being dictated not merely by prudence and self-interest, but also by justice and neighbourly good feeling. Although the companies are, by Act of Parliament, furnished with power to lay down their mains and services to a large extent irrespective of the public convenience as to time, manner, and vested interest, yet it is very inexpedient that their engineers or contractors should use their power in an arbitrary manner, and it is also injurious to the progress and advantage of the companies themselves that such a course should be taken. Even the effort to accommodate the public in the simple matter of time may be attended with great mutual advantage. For example, by means of working by night instead of by day, the Great Central Company were enabled to lay down the mains and services for the whole City of London almost in the same period lately taken by another company in merely laying the mains of two streets (Gresham and Coleman Streets).

Secondly, as regards the purity of the gas. During the whole time of my contract with the Great Central Company, the official analyst, Dr. Letheby, stated that he had never found more than 20 grains of sulphur per 100 feet of gas, and never more than six grains of ammonia to the same number of feet. Hence, in fixing the standard of purity for that company's gas, he gave the largest quantity which he had ever discovered in it as the maximum degree of impurity to be sanctioned. It is, therefore, deplorable to find that of late years the supply of gas which has been forced upon the City of London is so highly charged as it is with bisulphide of carbon. Whereas, by removing the ammonia and using wet lime alone, or oxide of iron and wet lime unitedly, and

drawing the retorts before the last dregs of gas have been extracted; or, in other words, by not insisting upon too large a produce of gas per ton of coals, no complaints such as have been so prevalent and troublesome of late need ever be made.

Then as to the illuminating power. To refer once more to the Great Central Company, it is well known that my contract with it as engineer for the manufacture of its gas made an allowance of one halfpenny per 1000 feet for each increase of one candle, from 10 to 16, and be it remembered not tested with a "London burner," but with the old "Dixon's Argand burner," the one which was referred to in the regulations laid down for instituting comparisons as to the standard "candle."

Then as regards price. It is quite evident that this must depend upon many circumstances. It involves necessarily, and as a principal element, the capital expended in the construction of what ought to be useful works, and not wasted in mere embellishment, having reference also to the cost of the wear and tear of the apparatus, the quantity of fuel for the necessary carbonization, the price and quality of the coals employed, the care and attention given to the other residual products, and the labour employed.

Allow me, therefore, to suggest under this head that the members of this association be invited to prepare papers on the question, entering into all these particulars, which should also be considered in their relations to the kind and description of retort used, to the mode of setting, to the size and construction of the gasholders for storeage, to the extent and nature of the buildings erected, the dimensions of the mains and services, the mode of purifying and condensing the gas, and the scale and position of the works. Each suggested improvement might, with much advantage, be illustrated by familiar examples, or by references to the writers own experiences, both as regards failures and successes.

Undoubtedly the gas companies at the present time possess great power and influence, and are in a most prosperous condition. It will, however, be their true interest to use their influence with discretion and moderation. The supply and management of gas is but little understood by the general public, and it is the very nature of ignorance to be suspicious and apprehensive of exorbitant demands. Hence it is not to be expected that, at least to the same extent as in the supply of many other articles, the gas companies should reckon upon the entire approval of the general body of their customers.

But inasmuch as a strong feeling exists in the public mind that some degree of competition in the gas supply is necessary to the common interest, and in order to prevent the inconveniences of monopoly, it will be the true policy of the companies to exercise great care lest any violent outburst of general dissatisfaction should be excited by undue charges, or the supply of gas of inferior quality.

Hence it is very desirable that the companies should be prepared at any time to prove that they have used their power with liberality and discretion. And it will be a most valuable service, on the part of members of this association, to avail themselves of every mode and opportunity of bringing about such a condition of the various gas companies that whenever an investigation may be necessitated they may be able to give satisfactory evidence that they have neither taken undue advantage of their position nor put forth exorbitant demands.

Yesterday I received a letter from our talented president-elect, Mr. Livesey, in which he, after expressing great regret that he is utterly unable to attend the meetings in Edinburgh, requests me to bring before the association a matter in which he takes great interest, and one also which has my warm and entire sympathy; but I regret that it did not occur to me to mention it in this paper until after I received his letter. He says: "There is another matter in which I take great interest, and therefore trouble you with it. I refer to the question of the suspension of Sunday labour in gas making. The subject has been regularly brought before the meetings for some years past, either by a paper and discussion, the report of a sub-committee, or the president's address I wish, therefore, to ask you if you can mention it in your address this time. You will remember that one of the demands of the men last year was for rest. on Sundays; and both the Chartered and the Imperial agreed to give it as soon as they could make proper arrangements. The Commercial, too, are now stopping from 6 a.m. to 6 p.m.; also the London, the South Metropolitan, the

Phœnix, and the Independent. If you can mention the fact that the movement is spreading not only in London, but in many parts of the country also, you will do good service both to the men and the companies employing them."

I will only add, let employers attend to the true interests of the men, and surely a day's rest on Sunday is calculated to make men better morally and physically; and sympathy and kindness to them as men will tend to raise a better feeling, and make them more willing to oblige those employing them.

I now give some account of a few of the inventions claiming attention, and also a short account of the papers now to be read, which has been furnished by your able secretary.

Clock Tower Lights.—There being a vast number of people whose interests, if not their immediate business, are connected with the Legislature and its debates, and to whom the hour of its rising is of importance, it was in 1870 thought by the Government that a signal light placed in the Clock Tower of the Houses of Parliament, and made to burn during the time of its sitting and extinguished at the moment of rising, would be of great advantage. The Government, therefore, sought for a light which could be made to illuminate the whole of an area of 180 degrees at any point within a distance of four miles. The first experiment was tried upon an arrangement contrived by Mr. Sugg, whose knowledge in reference to burners and light-eliminating apparatus is sufficiently well known to need no comment. It consisted of a wooden box with a ventilator at top, and into the front of which was inserted a glass globe filled with water 20 inches in diameter. Within the box and behind the globe were two semicircles of flat-flame lights, consisting of 42 burners, each consuming about 3 feet of cannel gas; or, on the whole, from 120 to 150 feet per hour, which gave a light of from 400 to 450 candles of the parliamentary standard power. This was used for about a month, when, in consequence of the heat, the box became charred and was finally burnt down. From the diagram (Fig. 1) on the wall the arrangement will be perfectly understood. During the preparation of another globe and apparatus, a similar one to that just described, but with a globe only 11 inches in diameter, was employed. These served throughout the session of 1871.

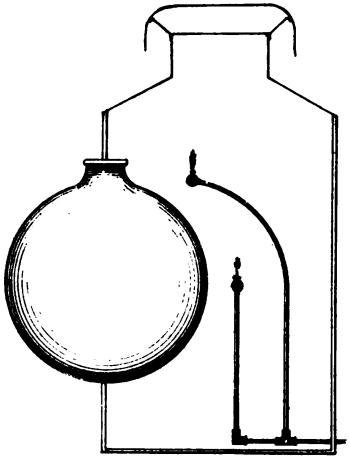
At the end of the session of 1871 the new globe arrangement was tried on the north side of the tower. The apparatus was somewhat similar to the one first described, but this time the box or lantern was made of wrought iron, to which was attached a cistern containing water, and provided with a filter so arranged as to furnish a continuous stream of filtered water through the globe, thus keeping it clear and cool. Forty-two burners were placed in one semicircle behind the globe, the consumption and amount of light being much the same as in the first experiment. The light given by this arrangement is the only one that has yet complied with the requirements of the Government—namely, to light at one and the same time all places situated within an angle of 180° and within a radius of four miles, and from the foot of the Clock Tower to the top of Primrose and Highgate Hills. Fig. 2 illustrates this arrangement.

The light exhibited in the session of 1872 was an ordinary catoptric harbour light, made by Chance Brothers, of Birmingham, fitted with an Argand burner made specially for it by Sugg, and a Fresnel lens. This apparatus is shown in Fig. 3. The rays were thrown horizontally in only part of a semicircle, and vertically from the Duke of York's Column to the top of Primrose and Highgate Hills, or concentrated into about 50°. The light emitted from it was as nearly as possible at Primrose Hill equal to Sugg's light, but at the Duke of York's Column, or about half a mile off, Sugg's was most intense, as will readily be understood when it is considered that the 180 vertical rays which were thrown out by Sugg's light were concentrated into about 50 by the catoptric lens. The quantity of gas consumed by the Argand burner was little more than half that consumed by Sugg's flat flames. No regular experiment comparing the actual consumption of the two was ever made, so that the quantity named is therefore only an estimate.

In the present session of 1873 two lights have been and are still in course of trial—the one a light designed by Mr. Wigham, and the other a magneto-electric light contrived by Gramm. A description and illustration of Wigham's light will be found in the last number of the JOURNAL OF GAS LIGHTING. It is, however, a vibrating light, and only lights a portion of the

CLOCK TOWER LIGHTS.

Fig. 1.



Plan of Fig. 1.

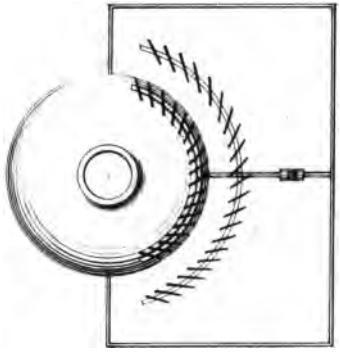


Fig. 2.

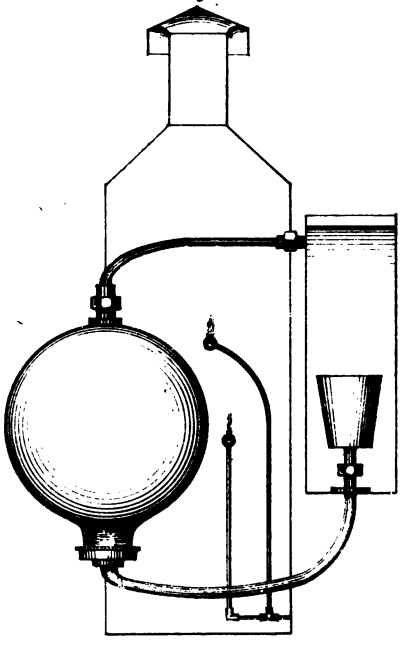
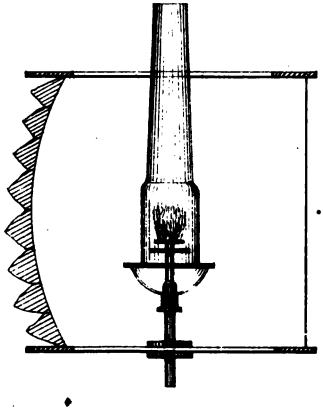


Fig. 3.



Whiteman & Bass, *Litho to the Queen*, 236, Holborn, London.

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semicircle at a time, and in a downward direction the rays strike from the Duke of York's Column to Primrose Hill. The consumption of gas varies from 300 feet per hour to 12,000. The illuminating power has not been determined.*

The magneto-electric apparatus of Gramm is fixed in the basement of the Clock Tower, and is driven by an engine formerly used for Reid's ventilating apparatus. The conducting copper wire or road is half an inch in diameter. The light has a deflecting and vibrating apparatus by which the ray is made to impinge upon any part of the semicircle, but only one pencil of light is thrown in one direction at a time.

From the "Standard," May 30, 1873.

"*The Electric Light at the Houses of Parliament.*—We have already described M. Gramm's admirable electro-magnetic machine in considerable detail, but as the members of the press were on Monday night invited into the Clock Tower, where the light is burning, we may well take the opportunity of describing the exceedingly ingenious mechanical and electrical arrangements devised by Mr. Conrad Cooke in the lighting apparatus itself. The given object being to throw the light beam in various directions at stated intervals, the mechanical arrangements had to be brought into harmony with the electrical currents. The exchange of lamps, too, had to be provided for in a sufficiently rapid way that there should be no practical break in the signal light. This not on account of any possible accident, but for the reason that the carbon points will only burn four hours, and the House often sits eight and ten. Three distinct mechanical motions had therefore to be arranged. In the first place, however, a solid fixing had to be given to the whole apparatus. To this end a solid fixed table is made the basis of the entire system. Upon it is a gun-metal ring or tram, and through the centre of the table a pin of gun-metal is brought up; over this is a second rotating table, mounted on metal rollers which run on the circular tram on the fixed table. The gun-metal pin is brought up through this rotating table also, and forms a pivot for it, and there is a rack and pinion motion along the edge of this table for moving it. The rotating table thus provides the training of the beam, if we may use the expression; but to give the elevation and depression, a third table, hinged by two hinges at the fore part, is added, and at the rear of it is an elevating screw working against a reciprocating nut. To this third table the holophote is attached at right angles to its surface. As the elevating screw is worked the rear is raised or depressed, and the angle of the beam is altered accordingly. Now, to accommodate the electrical current with this, the wire leading from the negative pole of the machine is attached to the base of the metal pivot. From the right metal hinge a metal lever extends to the top of the pivot, upon which it moves when the table is rotated. A wire leads from this hinge also along the top of the third or elevating table to a metal stud in the fourth or lamp table which stands fixed on the elevating table, and this stud forms the terminal of the negative wire. The positive wire from the machine is attached to a metal tram or ring on the fixed plate. From one of the rollers a stud comes up through the rotating table, and a wire connects this stud with the left hinge, from which again a wire leads to a second metal stud on the lamp table, forming the positive terminal. The two lamps are carried on a miniature trolley, at the bottom of which are two sets of metal springs so adjusted that when one lamp is in position in the centre of the holophote its springs are in metallic contact with the two studs by which the electrical currents flow. As this is run off the springs of the other lamp come into electrical contact, and so on, and in this way the changing of the lamps brings one light into play as the other goes out, and the practical continuity of the signal is maintained. The view from the lofty eminence of the tower

* Since the above address was delivered, the secretary has received a communication from Mr. Wigham, stating that his invention complies with all the Government requirements, that the light illuminates continuously, in one fixed beam, an arc of 180 degrees, and has a vertical range from Palace Yard to Primrose Hill. That the light admits of being used in five different degrees of power, according to the state of the weather, and that the consumption of gas corresponding to these degrees varies from 3 to 215 feet feet per hour. That the apparatus is divided into three burners, the lowest being placed in the focus of a cylindric refracting belt, by means of which the illumination of the arc of 180° is maintained without intermission, while the two upper lights may be used in conjunction with reflectors, refractors, or annular lenses; and thus, without affecting the continuous light, cause a distinction very useful as a signal.

excited great enjoyment, and the various effects produced by the wonderful light were closely scrutinized and admired. Colonel Stuart Wortley, who has taken great interest in the light, and issued invitations, was present, as also were Mr. Werdermann, the proprietor of the English patent, and who has himself, we believe, introduced matters of considerable interest in connexion with the invention, and Mr. Edwards, a gentleman who has likewise interested himself greatly in the success of the light. To Mr. Conrad Cooke too much credit cannot be given for the perseverance, ability, and skill with which the whole of the details, as well as the general arrangements, have been carried out."

Eldridge on Coffey's Still.—The writer of this paper explains the construction, and advocates the use of Coffey's still for the extraction of ammonia from gas, principally on account of its giving no pressure, and ensuring that the whole of the gas shall pass through a considerable quantity of water in the course of its ascent.

Warner's Paper on Distribution, &c.—Assuming gas to be good and the manufacture economical, Mr. Warner points out that the satisfactory lighting of a town is dependent upon a perfect distribution, and as this cannot be accomplished without a thorough acquaintance with the machinery for the purpose, it is necessary that a perfect registration of the whole of the details should be made, and then again classified and tabulated for reference and comparison. To gas managers, it is said, a moment's reflection is not needed for it to be seen how close is the relationship between this subject, complaints, and unaccounted-for gas.

Parlby on Stopped Ascension-Pipes—In this paper the cause of stopped pipes is attributed to high heats, allowing the charge to remain in longer than is necessary to drive off the gas, too deep a seal to the dip-pipes, irregularities or defects in the casting of the ascension-pipes, and a hydraulic main of insufficient size to carry off the gas freely. The remedy is the avoidance of these errors, and taking care to charge the hottest retorts with a proportionately heavier charge, so that the whole may be worked off in the same time.

Green on Stopped Pipes.—Mr. Green, in his paper on stopped pipes, advises the use of a screen placed in the retort mouthpiece, between the ascension-pipe and the charge, as a remedy, and states the success that has attended his plan.

Methven on Coal Wasted in Gas-Works.—This paper points out how advisable it is to have a competent manager, and make him responsible for the coals consumed. The remarks are directed principally to very small works.

Emmerson on Unaccounted-for Gas.—The author considers it absolutely necessary to take a fair start in tracing the causes, and that due correction should be made for temperature, &c., when determining the amount of gas actually made, in comparison with that recorded by the station-meter, and attributes loss to a variety of causes, such as unsound gasholders, small and imperfect pipes and careless main-laying, unsuitability of joints for the ground in which the pipes are laid, chipping instead of drilling holes for services, want of provision for equalizing pressure in hilly districts, unregulated public lights, and want of attention to the keeping of their services in good repair, improper selection of meter to suit the particular place and circumstances under which it is placed, and neglect of a periodical inspection. The remedy is, of course, prompt and regular attention to all these points.

Skelton's Paper on Gas Street Lighting treats on the various forms of lanterns invented for utilizing as much as possible the rays of light which in the ordinary lamp, if not lost, are made but little use of, and divides the lanterns into three classes—radiating, refracting, and reflecting—and comes to the conclusion that the catoptric lamp, which is his own invention, is the best. He also notices the method of lighting by the rod, and an improved method of closing the bottom of the lamp.

Hartley's Paper on Coal Gas as a Fuel.—Mr. Hartley draws a direct comparison between the cost of gas and of solid fuel (coals) as a heating agent for steam-boilers, showing the great economy of coals on the large scale. He then makes a similar comparison in respect to cooking on a large scale, principally in respect to boiled or steamed food. Great waste of heat is shown to arise from the use of gas for merely boiling as compared with steaming food. Some consideration is given as to an open gas fire and to an open coal fire for boiling and roasting, and advocates the use of gas for roasting and baking under nearly all circumstances. He then enters upon the character of heating gas stoves, and

divides them into simple cylinders, multiple cylinders, tubular stoves, reflector stoves, and stoves with solid heated materials. He advises the use of the latter in conjunction with a large radiating or conducting surface. He insists upon the ventilation of all heating stoves as indispensable, and concludes by showing the advantages of gas, spite of its cost, for heating conservatories and similar places.

Frith's Paper on Book-keeping.—Mr. Frith in his paper explains the system of double entry, which he describes as one which is sometimes thought to involve double labour as well, but asserts that what is worth doing is worth doing well, and that in reality, especially where the manager acts as engineer, secretary, and other officers as well, the system he advocates is in the end far less troublesome and infinitely more correct and satisfactory than any modification or extension of the single-entry plan. He expresses surprise at hearing of a company with £370,000 capital working without a cash-book, and states that the imperfections or absence of system in the keeping of books and gas companies accounts that have come under his notice has induced him to lay before his brother managers what he considers to be a concise and simple plan.

Gore on Substitutes for Coal in the Manufacture of Gas.—Treats upon the use of oils, resins, wood, mineral pitch, the decomposition of steam and its subsequent carburation, and the carburetting of air. He reviews the different apparatus and processes employed, and gives the result of his experience and observations in many towns on the continents of Europe and America, the conclusion being that there is no material or process superior to that generally employed in this kingdom.

Jones on Gasholder Capacity compared with Consumption.—From returns made to him from 153 gas-works he finds that the average is 89·77 per cent. in comparison with the maximum daily of consumption, and that the extremes range from 32 to 200 per cent.

Dempster on Choice of Materials and Construction.—Relates to the selection of proper fire-clay for the uses to which it is to be applied, and refers to the construction of chimneys.

Paterson on Flow of Gas through Pipes.—This paper gives a brief history of the discovery of the laws which govern the flow of gas through pipes. The accuracy of the co-efficients from which the formula has been determined compared with the results of experiments made by the writer in 1872 on a 16-inch main. He considers that if any modern experiments seem to require a modification of the constant co-efficient 1350 to tally with the results, the probability is that inaccurate values have been attached to some of the data, and that with the exception of two slight errors he considers the article in "Clegg" as the most valuable elucidation of the subject which has yet appeared, and a safe and reliable guide in the hands of the gas engineer.

Sugg's Paper on Standard Burners.—Mr. Sugg describes the first standard burner, and states Mr. Hughes's ideas thereupon, the principle laid down by him being that the burner which developed the illuminating power the least was the proper one for what he (Sugg) calls "adverse" testing. He then describes the Birmingham standard burner and its defects. The Leamington burner is treated in the same way, as also those for Dublin for 16-candle and for common gas. Consideration is given to the principle enunciated by Mr. Cardwell's committee—namely, that the companies had a right to demand the use of that burner which gives the best results in illuminating power, and is at the same time suitable for consumers in ordinary use. The result of this was the construction of the London burner, and its adaptation to cannel gas. A description is also given of the Dublin cannel gas-burner and its defects, and reference is made to the gas referees standard cannel gas-burner. Mr. Sugg next examines the question from different points of view with regard to the employment of flat-flame burners for testing the illuminating power, and finally shows his views as to the requirements for a standard burner, and proposes to use a system of standard burners which would obviate the difficulty which arises from the present unsettled state of the question.

Proposed Establishment of a Benevolent Fund.

At the close of his address,

The President said: The first matter on the *agenda* is the reception of a report from the committee on the establishment of a benevolent fund. Since the last meeting a circular has been sent to each member of the association,

with the view of ascertaining the probable extent of support which such a fund would receive, and the committee have unanimously come to the conclusion that the answers they have received are such as would not justify them in recommending the establishment of such a fund in connexion with the association. Upon this subject, however, a report will be presented to the meeting at a later period, which I have no doubt will meet your approval.

Mr. J. ELDRIDGE (Richmond, Surrey) read the following paper on

THE APPLICATION OF "COFFEY'S STILL" FOR THE EXTRACTION OF AMMONIA.

At most of our annual meetings the attention of members has been called to the various modes of washing, scrubbing, &c., with a view of extracting ammonia and other impurities from the gas before it reaches the purifiers.

When sulphate of ammonia is made in large quantities a vessel called a "column," or "Coffey's still," is used, in which ascending steam is made to come in contact with descending streams of ammoniacal liquor, and the ammonia thus becoming vaporized passes from the still through a pipe to the saturator.

A similar vessel is sometimes, though not frequently, used on gas-works. I have one in use on our works, and as it has proved very effective I now propose to give a brief description of its construction and working for the benefit of those who may not have seen one. It can be made of any dimensions. The one shown on the drawing is 24 feet high, 4 feet wide, and 2 feet thick, cast in eight 3-feet lengths, with flanges, and put together with bolts, nuts, and lead pipe in the usual way.

From below the outlet to just above the inlet are a series of shelves 3 feet 4 inches long, and about 8 inches apart, thus leaving an opening of 8 inches by 24 inches at each end. These shelves rest on fillets cast on the side of the still, the open end of the one being over the end of the other, which is not open, and in some measure resembles a series of steps. On the open end of the shelf is a ledge half an inch high, so that each one has always water over it to that depth. The water is pumped in at the top of the still through a 2-inch pipe, when it falls on the first shelf, runs over the ledge at the end to the next one, and so on down through the whole till it reaches the bottom, thus forming a continuous stream of 2 feet wide and half an inch thick, as well as a series of small waterfalls. The water runs out at the bottom into a tank, where the outlet-pipe is, of course, sealed in the usual way.

The pipe through which the water is supplied at the top may be of any size, or can be regulated by a valve so as to give whatever quantity may be thought necessary, according to the make of gas. The gas entering at the bottom of the still passes backwards and forwards in the course of its ascent, and comes in contact with all the descending waterfalls, and, of course, over the water on each shelf.

On the works of which I am manager we have a good-sized coke scrubber, through which we pump the ordinary ammoniacal liquor over and over again at the rate of about 1000 gallons per hour, till it is about 16° of strength. The gas then passes through the still, in which water is used at the rate of 1000 gallons per hour, till it is about 8° of strength, and it is then used for making sulphate.

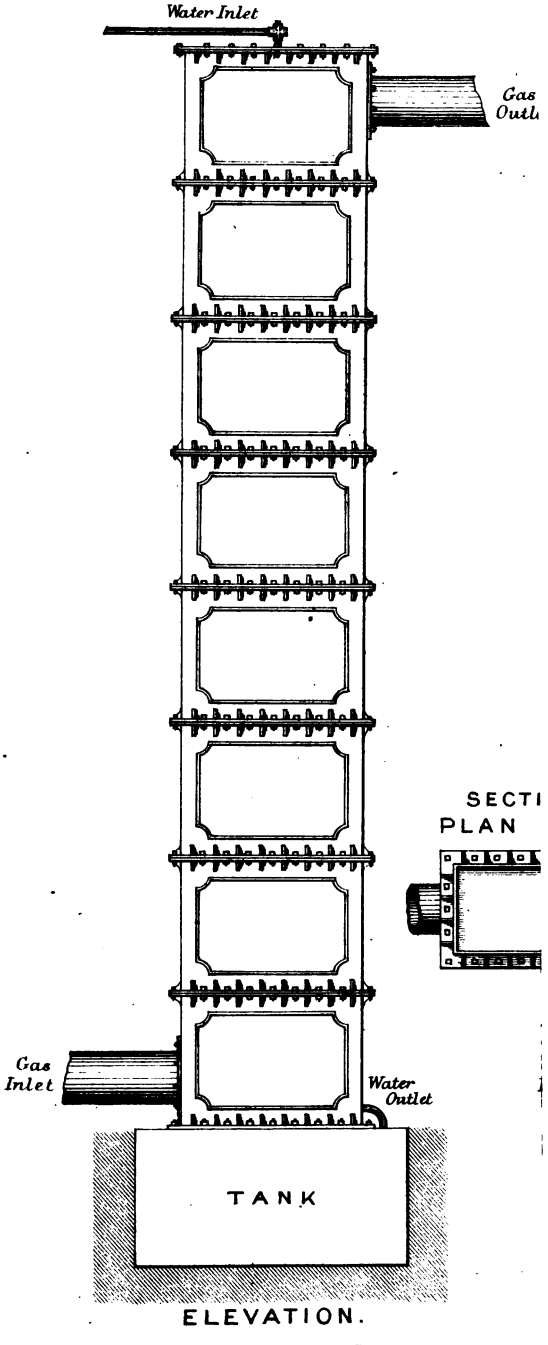
A large quantity of ammonia passes from the coke scrubber into the still, where it is arrested, it being impossible for the gas to make its way up to the outlet without the whole coming into contact with the descending fluid.

In the ordinary coke scrubber the tar and coke frequently become nearly a solid mass, causing a great deal of pressure. Mr. Anderson, when speaking on this subject at Nottingham, in 1867, said "he had seen, at the opening of scrubbers, certain sinuous channels through the coke, which channels were glutinized with tar."

In the still the least obstruction is impossible, and the pressure is therefore *nil*—a feature which all managers will readily appreciate. I am aware that scrubbers charged with boulders, brickbats, broken bottles, drain-tiles, &c., or fitted with boards, are less liable to become obstructed by tar than those containing coke; still the remarks about pressure apply more or less to the whole.

COFFE

as applied to the



Whiteman & Bass, *Litho to the Queen*, 236, Holborn, London.

UNIV. OF MICH.

Another advantage of the still is that it requires no distributing apparatus; the water is simply pumped in through the pipe on the top, and rushes from shelf to shelf till it reaches the bottom.

We all know that in the ordinary coke scrubbers there are frequent difficulties in the distribution of the liquid. The "Barker mill" will sometimes get out of gear; the revolving brushwood—excellent as the plan is—sometimes gets clogged with tar; the simple perforated pipe becomes partly stopped, so that it is not an uncommon thing for the gas to be passing through what may in some measure be called a dry scrubber. This is impossible with the still.

Another advantage is that the still is very simple and economical in its construction.

I wish to say, in conclusion, that these few remarks on rather an important subject are respectfully offered to those who, like myself, are managers of comparatively small works. Speaking from experience, I have always found in the use of the still that the whole of the ammonia has been taken out of the gas, and of course utilized, and the expense of purifying materially reduced.

My object in reading this short paper will be attained if I have succeeded in bringing to the notice of my brother managers a vessel which I think ought to be better known and more in use on gas-works than it is at present.

Mr. ELDRIDGE said that Mr. Sugg first called his attention to the Coffey still, and strongly advised its use. He might further state that Mr. Barclay, of Tottenham, had used the still with great success for a number of years.

Mr. MAY (Canterbury) said he should like Mr. Eldridge to explain to the meeting how he got rid of the tar which accumulated on the shelves.

Mr. DOUGLAS (Waltham Cross) remarked that the application of Coffey's still to the manufacture of sulphate of ammonia was no new thing.

Mr. SYMS (Rochester) suggested that the value of the process would be much more intelligible to the meeting if Mr. Eldridge would give the proportion of water per 1000 cubic feet of gas instead of the quantity passed per hour.

Mr. WARNER said the reader had suggested doubts as to the stoppage of washers, but for his own part he could not understand why boards placed perpendicularly, or only at a slight inclination, should be more likely to stop up than horizontal bars. In the paper read before the association upon scrubbers, two years ago, it was clearly shown that with boards such as Mr. Livesey and he (Mr. Warner) employed there was no tendency to stoppages.

Mr. WATSON (Sydenham) asked for information on two points—first, whether Mr. Eldridge relied entirely upon this scrubber—for after all it was a scrubber—for the removal of ammonia; and secondly what amount of ammonia per 1000 feet was left in the gas after passing through it.

Mr. GEO. ANDERSON (London) said he had been in hopes that the paper just read would have gone into some statistics as to the manufacture of sulphate of ammonia, because the fact of that article being made by Coffey's still was an old affair. All the members of the association who were present at the meeting held in London some seven years ago, and paid a visit to certain chemical works there, had the opportunity of seeing the manufacture of sulphate of ammonia upon a large scale entirely by the use of the Coffey still. Perhaps Mr. Eldridge in his reply would be able to furnish the meeting with some facts showing the economy of the process he adopted, the amount of acid necessary, the quantity of coals used per ton, and such other practical statistics as would enable them to judge of the value of the process as compared with other modes of manufacture. If he (Mr. Anderson) understood Mr. Eldridge aright that gentleman said he used a second still; if so, that was not a good mode of extracting ammonia. Mr. Eldridge stated that while the gas was passing upwards he had a stream of water passing at the rate of 1000 gallons per hour down the various shelves of this apparatus, and that in this way such a neighbourly action went on between the gas and the water that the ammonia was extracted. Now he (Mr. Anderson) must say he was afraid that there being a space over the water on each shelf and between it and the next there would not be so good a contact as if the gas had to pass through and alongside pieces of coke, saturated with water, of various sizes, large at bottom and small at top of the scrubber. Unless means were taken to cause the gas in very fine particles or divisions to

pass through the scrubber, he did not believe the ammonia would be extracted profitably from the gas. There was also another remark to be made. If the gas were allowed to go into the scrubber before the tar and all the liquid products were thoroughly extracted from it, he should not call that good engineering. In order to do that as far as possible in the works with which he was connected he used a water washer. In that washer he put the washings of the scrubber, as also the ordinary ammoniacal liquor from the works. By passing the gas through the ammoniacal liquor he got rid of the tar; and he might here state that he had a scrubber in use at the present time which had been in action since 1864 or 1865, and had never been opened until last week. It was then opened by his direction, not because it had ceased to act, but because at this season of the year it was well to inspect every kind of apparatus on the works. Certainly this scrubber had been in action during the whole of the time he had named, and there had never been anything wrong with it. He believed the cause of this was that he got rid of the tar before the gas went into the scrubber. In that scrubber he did not use ammoniacal liquor as Mr. Eldridge did, because he did not believe that by so doing he could entirely, though perhaps he might partially purify his gas from ammonia. If they passed gas through ammoniacal liquor of 6 oz. strength, for instance, and then passed it through water or ammoniacal liquor of 12 oz. strength, they would have their gas impure. To purify gas from ammonia they must either use some acid or allow the gas in passing last through the scrubber to pass through pure water. If they pumped ammoniacal liquor over and over again up to 16° strength, what was the result? Each time as the liquor became stronger and stronger the less affinity had it for extracting ammonia from the gas. Now he contended that all this pumping over and over again was a mistake. They had no business to pump at all, and if their scrubbers were properly constructed they had no necessity for it. They should put through their scrubbers as much water as was equal to the ordinary quantity of ammoniacal liquor. He was in the habit of putting 10 or 12 gallons of pure water through his scrubbers from the top, and he thus obtained 20 to 22 gallons of ammoniacal liquor per ton of 12 oz. strength throughout, and he had a practically pure gas. He believed that if the scrubbers were made high enough and the water was put through slowly, there would never be any necessity for pumping. Then in addition to the scrubbing there should be a previous washing to prepare the gas for the scrubber. Thus operating, they could, by methods long in practice and well known, perform all that was possible of attainment by any new and fanciful processes.

Mr. Eldridge, in reply, said Mr. May had asked how he got rid of the tar. His answer was he had never seen any tar in this still at all. He passed the gas first through a coke scrubber, and in that there was very little tar because he thoroughly condensed his gas, but in the still there was none. And even if any tar passed to the still it would not clog up the apparatus, nor obstruct the way of the gas. Mr. Syms asked the quantity of water per 1000 cubic feet he employed. At the present time in his works he used 1000 gallons per hour, passing about 7000 cubic feet of gas during the same period. Then Mr. Douglas said there was nothing new in the Coffey still. He (Mr. Eldridge) did not say there was. All he said was that the apparatus was used in some works, and it would be better if used in more, and his intention in reading the paper was to call the attention of those gentlemen to its value who had never hitherto employed it. Mr. Warner did not agree with his comparison of this still with scrubbers in which boards were used. But he did not mean to say that in all cases where boards were used there must necessarily be stoppages, but that there was a tendency in almost all of them to that result, whereas in the Coffey still it was perfectly impossible. Mr. Watson asked whether he depended upon this still alone for the extraction of his ammonia. He had already stated that he first used a scrubber charged with coke, which took out a considerable portion of the ammonia, so much so that by pumping the ordinary liquor over and over again, he got it up to 140° strength. Nevertheless a great deal of ammonia did pass to the still, otherwise he should get the water pure. He found, however, in the winter that after using the still for a day or two the water came up to 7° or 8° of strength. Mr. Anderson and Mr. Watson both asked for statistics. All he (Mr. Eldridge) could say was that he had not gone into them at all, and did not read the paper with any reference to the manufacture of sulphate of ammonia. He

therefore could not answer the question as to the amount of acid necessary, nor the quantity of coals used in the manufacture per ton of sulphate; his object had simply been to show the utility of the still in the manufacture of gas. He might state that only a short time ago he had occasion to stop the still for about twelve hours, and his purifiers were off twelve hours sooner, which he thought was conclusive proof with regard to the value of the apparatus in purification. Since he had had the still in operation the produce in sulphate of ammonia had been very much greater. The question was asked whether the still did really take out the ammonia. The fact he had stated, that by using clean water he obtained, after a while, 7 or 8 oz. liquor, was a proof that it did take it out.

The PRESIDENT said the association was much indebted to Mr. Eldridge for his paper, which had brought the subject before the meeting in the shortest possible way, and which contained a great deal of useful matter. With regard to the Coffey still, Mr. Eldridge had very fairly stated that he did not bring it forward as anything new. To his (the president's) knowledge this still or scrubber had been used in the manufacture of sulphate of ammonia for a very long period. The first application of what might be called an approximation to the Coffey still, was a condenser erected by the Dover Gas Company 30 years ago. It was in the form of a flat worm. The hot gas was admitted at the top and the cool gas passed out at the bottom, so that the condensible matter met the gas in the opposite way, and it was the most effective condenser he knew of. The same plan was adopted by Mr. Barclay, at Tottenham, where the main was put up as a boundary to the works. It was laid in a horizontal position, with a slight fall. The gas went in at one end, the condensible matter met it in the opposite direction, and it became a most effective scrubber.

Mr. WARNER asked whether the condenser at Dover was in use before one of the same kind was used at Birmingham.

The PRESIDENT said he could only state that it must have been about 30 years ago.

Mr. GARNETT (Ryde) said there was one at Portsea 35 years ago.

The PRESIDENT remarked that it was thus we sometimes thought we had something new, which, upon investigation, was found to be very old.

Mr. WARNER (South Shields) read the following paper on

THE DISTRIBUTION OF GAS AND THE IMPORTANCE OF HAVING A COMPLETE AND PERFECT REGISTER OF DISTRIBUTING PLANT.

This title is exceedingly comprehensive, though the subject is entirely beyond the scope of a single paper. I shall therefore deal with it in a similar manner to that of the governor and governor-house—dwell rather on the broad principles of a systematic arrangement of the work than enter into its details. The subject, though not attractive, is one of considerable importance; indeed, to some companies, none more seriously affects their interest than distribution. With a normal rate (if it can be fixed) of "unaccounted for"—say 15 per cent.—there is much in the subject to engage the closest attention of gas managers; but with 20 and 25 per cent. and upwards, and with complaints more or less frequent of irregularities and insufficiency of supply, we have in this subject one that demands thorough discussion by the practical and experienced members of this association. To commence the work, I enter a town and take stock, as it were, of the distributing plant—mains, services, meters, and public lamps. The latter being the easiest to dispose of, I take them first, and will follow the others in the same way, the inverse order in which they are placed—meters and services, then mains, and matters pertaining to each severally at the same time.

For distinct and separate account of the work, and for the purpose of a perfect check, I use in some cases three "forms." The first for "The order in which lamps are lighted in walks," which has columns for "Name of street or place," the "Number of lamps" in it, and the "Numbers on the lamps."

From this we get then the total number of lamps lighted from the number in each "walk." This work is then checked by the next "form," "The arrangement of streets, places, &c., in alphabetical order," with columns for the same, "Number of walk," and "Number of lamps in the street." These two "forms" are sufficient for towns with *each street* numbered from unity;

but in towns with the lamps numbered consecutively in the town, another "form" is necessary to register them in this order; this has columns, as in the other "forms," for "Street," "Number of walk," "Number of lamps," and "Numbers on lamps." A word on the two systems of numbering. The latter *appears* to be the most simple, but practically the former is the most satisfactory, as each street may have its lamps altered, and the number increased or diminished without affecting other portions of the town; but when arranged consecutively, alterations in position or number create considerable confusion. In the inspection of the lamps, each one has a mark painted on it when booked, to denote the same, and at the same time the pillar, &c., are inspected, and the condition reported. The "form" of "Daily report of public lighting" is shown in next diagram; its columnar arrangement is—"Number of walk," "Name of lamplighter," and for each day in the week, "Number of lamps in walk," "Number not lighted at night" (ordered or otherwise), "Number out in the morning;" at the foot of the page are lines for details of alterations, and change of number is at once made in the "walk" in which it occurs, and the total number at foot of column corrected. There are also columns for totals "Not lit" and "Found out," which are made up of the cross castings of daily reports; thus is shown the comparative condition of each man's walk. The totals are also compared with "Police report of lamps out," in line at the foot of the tabulated arrangement.

In the general inspection of a town for the purpose of ascertaining the condition of the plant and nature of the supply, nothing less than a house-to-house visitation will be satisfactory.

In this city I believe it is customary to have an annual inspection of this character; but then the social conditions here are different from English towns, and what is *necessary* in a large Scotch town, with its dwellings in great blocks of buildings arranged in "flats," and gas circulating freely through many, very many tenements, is not required in a quiet English town in the south of England. It is, however, necessary in *every* town that a *thorough general* inspection should be made more or less frequently, according to the character of its inhabitants and the nature of the district. For this inspection I have a "General inspection book," arranged with columns for "Names of streets," "Number of houses in the street," "Names of consumers," "Number of house," "Number of burners," "Size and description of service," "Size of meter, wet or dry," "Number of meter, and owner," "Date of meter," "Maker's name," "Last date of repairs of meter," "Private lamps, number, and how supplied," "Condition of service and meter, and remarks." From this book are posted the services into a permanent "Register of houses and services." This is arranged with columns of "Streets alphabetically arranged" and "Number of houses;" it has also linear and columnar spaces equal to the number of houses, for the size and description of service, also space for detached buildings, unnumbered houses, remarks, &c. As this is a permanent register of services only, it is not used for totals or yearly reports. The "form" for this work is shown in the next diagram, which condenses the work, and gives the total number of each size of service and description in each street. We have now to return to the "General inspection book" for meters; and this subject, I am afraid, we shall find a little more complicated, as we not only require the *sorts* and *sizes*, but the *dates*, to form a true estimate of the character and value of these important and valuable instruments. With such a mass of figures as there must be in every good-sized town, it is necessary to have a frequent and perfectly satisfactory check as the work proceeds, and for this purpose the inspection book is analyzed page by page, and at every tenth folio the preceding pages are summarized, as shown in the diagram of "Summary of pages." The total quantities of each sort, wet and dry, and the owner, company or consumer, are thus brought together. Under the two major headings, "Company's" and "Consumers" are arranged columns of sizes and lines of dates, the two top lines being "No date" and "Prior to 1854," and under these are lines for the 20 years up to the present time. Wet meters are entered in red, and dry in black ink. The casting of columns will give the total number of each size of meter, and the cross casting the total number in each year, the castings and cross castings agreeing with the previous totals of pages, the work is correct. If the total stock of meters in use was covered by the ten pages of the inspection book, it will be seen that nothing further would be

required, as we have the total number of each size in each year, and the total number of each year, also the total number of each size. In towns, however, with many consumers, it will be necessary to make an abstract of the work, and arrange it under its several years with columns of folio, summary, and sizes, which, by casting, will give the total number of each size in every year, as shown in the next diagram. These, copied into the previous "form," will give the stock. The same "form," with lines at the bottom for "Meters up and down," will give a simple and thoroughly reliable report of the meters in use.

I pass on to mains. Clegg says: "Experience has made manifest how necessary it is to have a perfect record of every feature in this part of gas lighting, and a good plan drawn to a large scale is the only available method that can be adopted; no written description will answer."

For the purposes of distribution, doubtless he is correct; but as a record of the work a map falls far short of a tabulated system. His remarks upon the want of a map may be well applied to himself upon this point. "Errors entailing a permanent expense and inconvenience have been the result of the operations of most of the great companies from this simple point having been neglected." He instances a case of twelve syphons having been used in the place of two; but surely here a list of syphons, with their position defined by their distances from fixed points would have been equally useful as a map, had reference been made to the list.

I do not wish to undervalue the advantage of the map; indeed, to quote Clegg again: "I would as soon think of making a steam-engine without a drawing as lighting a town without a map." I, however, contend for the advantages of a good and *full*, but simple registration of mains and their appurtenances. As an instance of the value of this in its crudest form, I have reported every day the position and size as well as the condition of each main as it is opened up, and so check the register and correct the map.

A list, too, of mains, with size, position, and their syphons, may be made, and made useful, by persons quite unqualified to prepare a plan. Such, too, would be far preferable to what I met with in one town in which I have been engaged. Upon inquiring about the mains, the reply was, "Oh, yes; we know all about the pipes. I will *walk over them* with you any time." I am afraid that this is the only reply that could be given to the question if put in some other places. Again, the written description is much better, more reliable, and more useful than the spider webs to be met with.

I place before you a genuine article of this kind, an official document, and, to do it justice, it is much more useful than many a one of a more pretentious character, or those maps with *mains drawn to scale*, or the sizes shown by different colours.

In a town in the south of England I met with two of such maps, one of which must have cost rather a long sum for mounting alone, as it was prepared in many sections, and some of these could not be fitted to each other for reference. To instance the necessity of *great care*, saying nothing of skilled experience, in the preparation of such plans, I give a sample of what I met with there; in one case a 3 inch and 4 inch were shown on one map, on the other a 5 inch, and another "walking over gentleman" thought it partly a 5 inch, but when examined it proved to be a 3 inch and a 4 inch. In another case a 3 inch was shown in several streets on the first plan prepared, but no main was shown on the second plan, nor was anything known of one by the principal men; a 3 inch, however, was found. Another case, a 3 inch was shown on one, and a 4 inch on the other. One more case only will I trouble you with. On one was shown a 4 inch and part of a 3 inch, and the other partly 5 inch and 3 inch; but on examination neither was correct, there being a 5 inch and a 3 inch the whole length. Hence the necessity of a system of constant supervision, registration of the work, and correction of the map.

The first "form" for this purpose is that of "Details of mains in streets alphabetically arranged." The columns are "Name of street," "Length of street in yards," Size of main," "Depth of main," "Length in yards," "Measured from starting point at——." "Starting point" is defined under "Remarks," the heading of last column, as "the point of intersection of lines drawn from the opposite (diagonal) corners of the streets or places." This plan clearly fixes the position of the main, which the next column is for the purpose of giving, the heading of which is "Distance of main from right-hand side of way, walking from starting point." The following columns are "Distance

of valves and syphons from starting point," "Date of laying," and "Cost per yard." The next "form" is "Register of mains." This is alphabetically arranged with column for the purpose, also one for length of streets; the other columns are for each sized main, from the lowest to the highest in the town, and several blank ones for larger mains when laid; there are also columns for "Mains through parishes or districts to supply adjacent ones," and "Remarks." The first minor column of "Size and length of main" is for pipes "under 2 inches."

I hope you will not think it out of place to quote Accum, 1819, as an authority on gas lighting, a case having occurred some time since as to the definition of "Mains." "The name of mains," he says, "is given in the strictest sense of the word to the cast-iron pipes from 2 inches in diameter and upwards, placed underground, for conveying the gas into smaller branch pipes; *but in a more extended* sense the term is applied to every pipe from which smaller ramifications or branch pipes proceed." The next "form" is for the registration of "District governors," "Valves," "Cocks," "Syphons," and "Standpipes." The last diagram of this series is that of "Yearly summary of mains and services laid and cost," with details of cost. The whole of the distributing plant may now be brought together in one sheet, forming thus "A synopsis of mains, services, meters, and public lamps" in each parish or district, with lengths of streets and number of houses in the same as shown by diagram. This sheet, I need scarcely add, is invaluable for reference and comparison; at one glance may be seen the quantities of mains of each size in each district, also the total quantity, and the same with meters and public lamps; also what proportion the length of main bears to length of streets; and what proportion of houses are supplied with services; and quantities of companies and consumers meters, and the totals.

In the matter of mains I have shown the importance of inspection and registration, in public lamps there are proofs of the same pressing necessity, from irregularity in the work through the change of men or otherwise, and in the fact of lamps having been discovered that were never charged for, and by reference to the "General inspection book" it will be seen that there is not, at least, less need of inspection and classification. The sheet is a sample page of *bonâ fide* cases that have just occurred in the case of a general inspection; a few, and but a very, very few out of many of the same character. The names of streets and consumers are fictitious, and the names of meter manufacturers omitted for obvious reasons, otherwise the entries are correctly copied from the "General inspection book." Let us look at a few of these cases. It will at once be seen that if such are to be found in a town where there is a fair amount of inspection and supervision, there cannot be otherwise than a large amount of unaccounted for, and a great many complaints in places less cared for. Look at the list:

No. of Case.	Consumer.	No. of Burners.	Size of Meter.	Service.	Remarks.	Tested.	
						In Normal Condition.	In Actual Use.
1	E. D. Smythe . .	15	2 lt. D.	—	—	—	—
3	W. Martin	24	5 „ D.	—	1850. Private meter, of which there are two in the list, and one of 1848.	—	—
4	Public Buildings .	282	60 „ W.	—	—	—	—
7	H. Marshall . . .	50	5 „ D.	¾ in.	—	9·09 S.	20·00 S.
10	D. Wilson	25	2 „ W.	¾ „	—	25·00 S.	35·00 S.
12	St. Luke's Church.	195	50 „ D.	—	—	—	—
18	Ramsey and Co. .	22	3 „ D.	½ ld.	—	3·38 S.	3·00 S.
23	Chapel	155	50 „ D.	1¼ in.	—	—	—
26	M. Thompson . .	10	2 „ W.	¾ in.	—	Not registering.	
27	R. Lindsay. . . .	16	2 „ D.	—	—	1·01 S.	0·99 S.
10		744	181 lights capacity.				

Some of these meters were subsequently taken down and tested, and the results are given in the two last columns, the first at the normal rate of burning, the second with the total number of burners in use.

One case (No. 10) was as high as 25 per cent. slow, which increased to 35 per cent. when tested with the full number of burners. The next case (No. 7) was 9·09 per cent. slow, increased to 20 per cent. with the full number of lights on.

An increased loss ranging from 0·20 per cent., the lowest, to 4·62 per cent., the highest, in nine cases, is shown, averaging above 2 per cent. loss in each case; and in two cases only is a gain shown—1 per cent. in one case, in the other 0·02.

Though there are but two cases of fast meters on this sheet, yet I must add that we do find meters considerably fast, and therefore the periodical testing will be equally satisfactory to the consumer as to the company. Can there then be, with such a state of things, aught but dissatisfaction with the supply, and considerable loss sustained by the company? And yet, where meters are not supplied free of charge, how difficult it is in many cases to get the consumer to hire or purchase a meter of sufficient capacity.

It will be seen that this inspection brings other matters to the surface—small services, as in case 18; bad inlet coupling; a lead service with end flattened up only; cock left on iron service, &c. The work is thus kept in a satisfactory condition, and the number of complaints kept exceedingly low.

In the matter of distribution proper we have little in theory or practice that was not suggested or in use in the early days of gas lighting—the governor, invented by Clegg, 1815; Malam's meter, 1819; the pressure register, 1823; turned and bored pipes, Peckston (1823) says, "some manufacturers have of late made, and in a comparison of weights of common spigot and faucet pipes there is not much difference in the castings;" and the great principle of modern times, that which has been so beneficial to the metropolitan companies—*districting*—was suggested by Lowe, 1823. Sir William Congreve suggested the use of large public meters on the mains, to show that the quantity of gas delivered by the companies corresponded with their contracts. Here, then, is sufficient proof that considerable attention was paid to this part of our business, and that in theory and practice details were elaborated that we should do well to copy rather than follow "Clegg on Gas Lighting;" for can anything be more opposed to a thorough and economical distribution of gas than what he directs: "It is generally sufficient, and always advisable, if possible, to have but *one* leading main from the works." Last year I had the honour of directing your attention to this subject, and attempted to show the advantage of having several mains from the works to regulate the pressure to the varying requirements of the several districts. But now I do so for another purpose—the *testing* of the districts—that the "unaccounted for" may be reduced.

Indeed, with the great loss sustained by some companies, it may almost be a question for consideration whether it would not be advisable, as it was in the case of pressure, to have a separate instrument for each district rather than one common to the whole—to have a meter or meters as well as a governor upon each main.

There are, no doubt, great difficulties in the way of "reducing the unaccounted for to a standard;" but it is not, as was said upon a notable occasion, "a perfect fallacy to attempt it." By dividing the town into districts, and cutting these up into sections, the leakage upon the mains and services may be traced, and by an examination of the public lamps, close attention to their lighting and extinguishing, and by frequent periodical inspection and testing of the meters, the "unaccounted for" may be reduced to so small a minimum, as to be lost "in condensation." It has been urged that the expense of districting a town is too great for the general adoption of the principle.

Doubtless in some cases the expense would be considerable, but in many towns the changes could be made gradually, and at a comparative small outlay; indeed, in some instances at a less cost than laying a larger leading main, much depending upon the judgment and experience of the engineer and a reliable map, as well as upon the nature of the district.

I have placed upon the table a specimen of service-pipe laid in a box of tar and sawdust in the manner in which I have had all my services laid for some

years now, which effectually protects them from corrosion and prevents their disturbance. Also, by the kindness of Messrs. Goldsmith and Dilkes, I have the opportunity of placing before you one of their patent service cleansers; it is no larger than a gas-tubing socket; indeed, it consists of one with a little hollow brass plug to screw inside, and a thimble to hold a piece of paper over this plug, thus forming a chamber for gunpowder, which is fired through the service into the main by a percussion cap in the usual way from a nipple on the other end of the plug. There can be no doubt of their usefulness and practicability, as they are in use by the Chartered, Leicester, Coventry, and Belfast Companies.

My subject is so closely related, indeed almost includes that of a paper to follow, that I am afraid I have scarcely avoided anticipating some of that matter. In this I trust that Mr. Emmerson will pardon me.

The PRESIDENT asked whether Mr. Warner had any practical proof that, by the inspection which he recommended, there had been a real gain in the matter of unaccounted-for gas.

Mr. WARNER said he had a case in point in which the unaccounted-for gas had been reduced from 25 to 30 per cent. during the last quarter to 11 per cent.

The further consideration of the paper was adjourned, and the morning sitting closed.

At the afternoon sitting,

Mr. W. B. EMMERSON (Darlington) read the following paper on

UNACCOUNTED-FOR GAS, ITS CAUSES AND REMEDIES.

This is a subject of vital importance to gas undertakings, and deserves the careful consideration and thought of all engineers and others who desire to see their companies successful in the highest degree. In the observations I have hurriedly prepared, I have no expectation that you will hear anything very new or novel; but rather, that your notice will be directed to some of the causes that in themselves seem insignificant, but which are playing an important part in swelling the account of gas, from which "no revenue is derived." And should the simple remarks thus made have no other result than to elicit discussion, in which some of the more eminent members of our association may favour us with their experience, the time will have been well spent. From meditation and observations made in reference to this subject I have arrived at the conclusion that the causes contributing to increase "unaccounted-for gas" are small in their nature, and to a very large extent under the control of the engineer in charge, but in consequence of the seeming unimportance of each individual cause, they pass almost unobserved and uncared for.

If more care was exercised in small matters of detail in manufacture and distribution, but chiefly the latter, the difference between gas made and sold in many instances would be very much less than at present.

The main object of some managers has been to obtain the greatest yield per ton of coal possible, and in this they have admirably succeeded; and with this object before them their works have been constructed upon the best and most modern principles. In them every appliance has been introduced which has become acknowledged as necessary for large and economic production, and some of us might fairly envy the perfection and method which is exhibited in carrying out their carbonizing arrangements; yet in some of these very undertakings the return to those who have embarked their capital therein has either been *nil* or very small, when compared with the profits of other companies who are not more favourably situated as regards efficiency of apparatus or district of supply.

A ready solution of such an unfortunate case may be found in the difference which exists between gas manufactured as indicated on the station-meter, and the quantity sold as seen in the aggregate return of private consumers meters, public lighting contracts, &c.

In searching for causes tending to increase the "loss account," it will perhaps be better to commence with the gas as measured at the works, and follow it in the distributory apparatus to the meter of the consumer. In doing this you will easily perceive that influences exist in connexion with the measurement of

gas at the station-meter, which, if not controlled, would materially add to the leakage account, although they could not possibly affect the gas sold. I need not remind you that the substance with which we have to do is in the highest degree elastic, and that the volume or space which it occupies depends very much on the pressure to which it is subjected, and also on its temperature. So that in order to compare the quantities made and sold, if the temperatures and pressures at which they were measured were not the same, there would be an error in estimating the difference, unless corrections were made to standards of temperature and pressure.

I have seen it stated that 5° of heat increase the volume by 1 per cent., and *vice versâ;* if this be so, it is evident that condensation of gas performs an important part in increasing or diminishing the unaccounted-for gas account.

As an illustration of this, I am acquainted with a work where 10,000 cubic feet of gas per ton was said to be produced from common coal and a very small proportion of cannel, but on the appointment of the present engineer, he found the temperature of the gas at the inlet of the station-meter to range from 75° to 80° Fahr., and the lime purifiers totally incompetent to remove sulphur compounds. This state of matters he attributed to imperfect condensation, and immediately set about improving and increasing the cooling arrangements, so as to reduce the temperature of the gas when measured to about 55°. The result was a lessened make as per station-meter by about 500 feet to the ton of coal, much more effective action on the part of the lime boxes, and a reduction of the "unaccounted for" from 22 to a little less than 18 per cent. Of course, so far as this went, the chief advantage gained was the improved manner in which the purifiers did their work, as the reduction made in the "loss account" did not affect the revenue.

The unsoundness of gasholders has in some cases been found to be a cause of considerable loss, sufficient attention not having been paid to their protection from the influences of the weather, corrosive action of the water in tanks, or gaseous exhalations which hover about gas-works. I have known a gasholder which, when filled and shut off from the town, lost, out of 14,000 cubic feet of gas it contained, 2000 cubic feet in 48 hours, and if the leakage had been allowed to continue would have emptied itself in a fortnight, the holder having been eaten through in several places, not through age and fair wear and tear, but from its being neglected to be cleaned and painted for several seasons previously.

This serious waste ought not to be permitted, nor such depreciation of plant allowed, for sake of the little care and expense entailed upon the application of some paint or other covering, having the power of resisting oxidation, and preserving ironwork from influences which attack it.

Another cause of "loss" may be found in defective main-laying, or in the pipes themselves being disproportionate to the district they have to supply. In many establishments inexperienced men are employed as main and service layers, to whom small wages are paid, the idea being too prevalent that no particular intelligence is required, and that any ordinary labourer is sufficiently qualified to perform the duties of a pipe-layer. This is a mistaken notion, as there is no portion of gas plant in which perfection of action so much depends upon the skill and care of the workmen, seeing that the very life of a gas company may be imperilled by the waste occurring through bad or defective workmanship. It is of the first consideration, therefore, to employ men who are intelligent and thoroughly conversant with the duties and responsibilities attached to the situation of a pipe layer.

Having secured skilful mechanics, the next point to be observed is that none but perfectly sound pipes are used, and it is worth while to employ some means of proving their perfection or otherwise, for where this precaution is not taken it is an easy matter for pipes to be laid in a fractured state, or be in some other sense unfitted to carry gas without waste. Where there is no provision made for testing mains by hydraulic pressure, a blow from a hammer will discover whether the pipe is sound, and service-pipes may be easily proved by having a connexion with a main on the works, to which, at one end, they might be attached, and the opposite end secured by a stopped-socket, and then, after careful inspection, a flame could be run along the pipe, and any imperfect place would at once show itself by the gas igniting.

In laying mains grave errors are often committed, where, for the sake of false

economy, small pipes are put down in districts they are inadequate to supply, the result being dissatisfaction to all parties concerned. It would be good policy to let all pipes intended as mains have a minimum diameter of 3 inches, because of the risk of fracturing smaller sizes by drilling them for the insertion of service-pipes. Small mains are fruitful sources of waste in more respects than one; in addition to the danger just named it is necessary to employ excessive pressure in order to give the needed supply to consumers, and it is well known by all gas managers that there is no more certain method of increasing the "leakage account" than by delivering gas at high pressures; and that, on the other hand, it has been demonstrated that you can in no way secure a better sale of gas per ton of coal than by keeping the initial pressure as low as is compatible with a sufficient supply at the consumers meter, and this can only be accomplished by a well organized distributory arrangement in which the pipes are laid down, sufficiently capacious for the duties they have to perform.

A diversity of opinion exists among gas engineers as to the best form of joint to adopt. Many, having some favourite idea, do not care to buy the suggestions of others, while those joints commonly in use—that is, lead and turned and bored—have each a great many advocates who point out the advantages of the one or demerits of the other; and although much may be advanced in favour of each, I believe that the wisest course is to consider the various circumstances as to the nature of the ground, the ease or difficulty to be encountered in laying the pipes, &c., and these should materially affect our choice. Believing, as I do, in a liberal eclecticism, selecting what seems best under the accompanying circumstances and applying it, the adoption of this principle will be found the most successful method of pipe-laying.

According to the preceding conditions, I would suggest the following as being the most suitable joints:—For instance, if the ground be hard and the line of pipe straight, nothing could be better than turned and bored joints, but if it was made ground, and with any tendency to subsidence, lead joints, from their disposition to become wedged, seem to be indicated. Again, where pipes are laid in shallow trenches, or in ground which from its nature is a good conductor of heat, and there is consequent liability to varying temperatures, causing extra contraction and expansion, there seems much force in the remarks of Mr. Rafferty, of Manchester, which he made at our Liverpool meeting—viz., that under such circumstances rust joints seem very applicable, as the joint and pipe would expand or contract in the same ratio, being of the same material. I have had some experience in the latter class of joints, and consider them to be very sound and durable, and think engineers might give them a more extensive application with advantage.

The patent list has been swelled by the patenting of many methods of jointing, all having for their chief object the reduction of waste. Many of these have been tried with varying results, and I know of none that possess any merit over the ordinary kind, except the one known as "Somerville's patent," a quantity of which I intend to put down for trial, with a hope that they have nearly all the good qualities of T and B pipes, without their rigidity and tendency to draw—a collar of lead run in a groove cast in the socket preventing that, and thus the drawing, one of the chief objections to T and B pipes, has been overcome.

A large number of leakages occur at the connexion of the service-pipe with the main, and I strongly advocate that all holes be drilled, so as to get them perfectly round, and tapped to a good full thread, and not gouged by the chisel, which in many cases results in an irregular-shaped hole and a defective connexion.

The districts supplied by some works are very hilly, and in many cases no provision is made for equalizing the pressure, being excessive in some places, and barely sufficient to meet the demand in others. This state of matters is the foundation of numerous complaints from consumers, some murmuring that the supply is insufficient; others, on the contrary, having so much that their gas bills are very heavy; or their lights are suddenly extinguished, and a great nuisance caused by the water being blown out of the index-boxes. To remedy this, some controlling agent should be introduced into the mains, where this undue pressure commences, preventing the terrible rush of gas to places where there is already an adequate supply. This can be effectually accomplished by the various dry district governors now made.

Public lighting, as carried out in many towns, may be credited with a large

quantity of the "unaccounted-for gas." In this department of supply much economy can be exercised, without in the least degree robbing the public of any light they are fairly entitled to. The contracts which companies make with "local governing bodies" are often very faulty, and of the most loose description, the only definite understanding being that so many lamps are to be lighted for a certain time at a fixed cost per lamp. The number of the burner, perhaps, is the only other matter stipulated for. Unless the company in this case were paid an extraordinary price, it will be plain that they must be considerable losers. For instance, if a No. 4 batswing was the burner specified, supposed to be a gauge for the supply of 4 cubic feet per hour, this might be the rate of consumption after midnight when the pressure would not probably be more than 7-10ths or 8-10ths at the burner; but the same burner would consume not less than 6 or 7 cubic feet per hour during the evening, when the pressure most likely would be double.

Calculations made of what the lamps used for a lighting season, on the former quantity of 4 cubic feet per hour, the difference of 50 per cent., when the burners would be passing 6 or 7 cubic feet per hour for several hours each night, would go to increase the "loss account."

Again, in some places the lamps and fittings belong to the local authorities, who arrange for keeping them in repair, by letting the work to some "contracting gas-fitter" for a certain sum per year. In these cases it often happens that the contractor's chief interest is to obtain his money, laying out as little as possible in repairs, and so long as he keeps the fittings so that the lamps can be lighted at all, does not care what leakage may be going on. In a case of this kind, I have known serious escapes remain without attention for several days after the contractor had received notice of the fact.

To remedy this, the lamps ought to be the property of the gas company; if not, arrangements should be made in the contract for a small extra payment for keeping the lamps in good order, which it would be their interest to do.

We now come to the instrument which records the quantity of gas used by the consumer, the "leakage account" depending very much on its accuracy. A well-made gas-meter is now considered a tolerably accurate machine; great ingenuity has been displayed in its construction, and in the application of the principles it embodies; and as now manufactured by first-rate firms, whose reputation is such that they would not stoop to any trade trick in order to increase their profits, but prefer the production of a sound, well-finished, reliable instrument, dependence may be placed upon it as a faithful register of the gas passing through it.

As you know, we have two kinds of meters in action, wet and dry. Each has its advocates, usually adopting one or the other exclusively. The idea forces itself upon me that circumstances should have something to say in the selection of a gas-meter. Cases exist where a dry meter is preferable to a wet one; for instance, where the situation is one of exposure to intense cold, and great trouble is experienced from freezing, or where the position is warm, and in a room higher than some of the lights to be supplied; under such conditions evaporation of moisture takes place, and is deposited by condensation in the fittings below, causing jumping of lights and other unpleasantness. Or where there is an excessive pressure applied to a meter, it frequently occurs, if it be a wet meter, that the water is either blown out of the index-box, or fills the waste-box, giving great annoyance to the consumer, as well as requiring extra inspection to keep the water-line correct, which under such conditions is almost impossible. In any of the preceding instances the advantages of a dry meter recommend themselves. But, on the other hand, should the situation be a cellar, in which there was dampness more than exposure to cold, or where the meter is fixed at a lower level than any of the lights to be supplied, so that condensed vapours from the meter may return to it again, or where the pressure from any reason is small, a wet meter is preferable. In every case discretion and thought should be used in the selection of a meter, choosing one suited to the situation and attending conditions, and the result will be a greater chance of correct registration, less liability to errors or to get out of order, with a material reduction of the "unaccounted-for gas."

But in any case there must be close periodical inspection, a record of the index being taken at each visit by the inspector, as well as of all defects observed, removing immediately every meter found out of action, or in any

way unfitted for its work. These are what present themselves to the writer as some of the chief cause of the excessive "loss account" which is seriously interfering with the commercial prosperity of many gas companies. The remedies have, no doubt, already suggested themselves to some of you while I have been reading. The following appear to be some of the most important:—Efficient condensation on the works before the gas is measured. A station-meter in thorough order, to register the gas correctly. Seeing that condensation has been proved to be an important part of purifying, it will be a benefit in two ways—first, it will fit the gas to receive the most favourable and effective action of lime-boxes, whereby sulphurous compounds will be reduced to a minimum; secondly, the gas will be measured at about the same temperature on the works as at consumers meters, preventing the seeming increase in "unaccounted for," so far as it results from difference of temperatures. Provide good large mains, judiciously selecting the kind of joint, care being taken to bed the pipes in soil, so that they are not destroyed by corrosive action, which often occurs in the iron-making districts, where new streets spring into existence like mushrooms, and are formed by depositing slag in the roadways, sometimes to a depth of several feet. An engineer who has this difficulty to contend against recently informed me that he had laid a quantity of new mains, and was compelled to remove them again in a few months; as some of them were by this time eaten through by the action of blast-furnace slag, or mill-cinder. To overcome this, tons of soil have been carted for the pipes to be bedded in.

Employ none but intelligent, competent men to lay pipes, and have every length of main tested before covering in.

In districts of varying levels, insert dry governors to control the pressure, delivering the gas at the lowest possible initial pressure as will ensure an ample supply to the whole district. Excessive pressure only increases leakage as well as condensation in the mains, depositing in the syphons valuable light-giving constituents; the tendency of all gases is to become liquefied as they are subjected to pressure, another result being to increase consumers bills, without giving them any adequate return.

In public lighting, where possible, obtain control over lamp-fittings, and keep them in thorough order; and if lighting under contract, introduce the average meter system, fixing regulators to every lamp.

Let consumers meters be regularly inspected, and use nothing but well-finished, substantial instruments, whether they be wet or dry.

If these suggestions were systematically carried out, with a renewal of those portions of the distributory apparatus most likely to wear out, such as service-pipes, every 12 or 14 years, there can be no doubt that the "unaccounted for" may in almost every case be reduced to 10 per cent. When I took charge of my present works, about 14 months ago, I was informed the leakage was 17 per cent.; but on making up the accounts for last half year, it was found it had been reduced to about 12 per cent.; the improved state of matters having been accomplished by attending to the details before named. I hope to reduce it at least 10 per cent., which is a sufficient allowance for all ordinary cases.

I now leave the subject with the meeting, conscious that I have given you nothing grand, and scarcely touched upon a subject of vast importance; and only hope that the paper may be supplemented with the opinions of the members, many of whom are so much more competent to address you than I am. Should they favour us with their valuable remarks, I shall feel amply compensated for introducing this subject to the meeting.

The PRESIDENT said the association were much indebted both to Mr. Warner and Mr. Emmerson for the last two papers read. They were very valuable because they were practical. He must be allowed, however, to say that he was very much inclined to attribute a large portion of the unaccounted-for gas rather to the want of efficient inspection or correct measurement than to the leakage from even bad joints and imperfect workmanship. There was not the slightest doubt that the greatest possible care, and the adoption of all the suggestions offered by Mr. Emmerson were desirable, but, after all, they were not sufficient. If the smallest escape of gas took place in a room it rendered the place almost uninhabitable—an escape which did not bear the proportion of one five hundredth of the actual consumption on the premises—and the result was the evil was immediately rectified. So would it be in the streets, so that he did not believe the evil with which they had to contend arose from leakage

absolutely as from the want of inspection, careful measurement, and the avoidance of stealage. He remembered many years ago that when he visited Scotland with the late Mr. Lowe they came upon a town, in the gas-works of which every foot of gas manufactured was accounted for. It was scarcely necessary to say that the manager was a careful man--and a Scotchman. Coming to England, Mr. Lowe told him of a case in which every foot of the gas manufactured was absolutely paid for. Why? Because the manager made every policeman an inspector. Again, he (the president) remembered on one occasion making an experiment, which no doubt some would think dangerous and improper, but then managers sometimes did things which were dangerous and improper without altogether considering what might occur. While engaged at the Brick Lane works, he one morning told the lamplighters to be about an hour later than the usual time in turning off the public lamps. Half an hour before the sun rose he had the whole of the gas turned off at the works for about five minutes. It was then suddenly turned on. The idea he had was that those who were using gas for private consumption would immediately detect the escape, and turn off their burners, the public lights remaining open. He then took the leakage, and found that the whole of the gas going along the main was accounted for by the public lamps then on but not lighted. With this experience in his mind, he would say that it was more to inspection and care in the measurement of the gas that they must look than to any other source. Mr. Emmerson had referred to condensation. It was quite true that one degree of temperature increased the dimensions or volume of gas by one 480th part, but it must be remembered that even when gas was measured at a high temperature it could not be much higher than the temperature of the atmosphere, therefore they could not look to any great extent for a remedy in this direction.

Mr. CRAVEN (Dewsbury) was rather inclined to attach importance to the remarks of Mr. Emmerson than to the registration to which the president had referred. At his works they were using the same means of registration they had heretofore adopted; but special attention had recently been given by him to the various matters alluded to by the writer, and during the last six years his leakage had been decreased from 28 to a little over 14 per cent. This was a pretty clear indication that in this direction they must look for the means of diminished leakage. One point to which Mr. Emmerson referred he thought was of some importance. He had always made it a rule when laying down new mains to take up the old mains. The neglect to do this was sometimes a prolific source of leakage. Another essential consideration was to have plenty of covering for the service-pipes and mains, so that they could not be easily deranged. Attention to these points would benefit many gas managers. In one other matter considerable improvement might be effected, and that was by the introduction of governors to street-lamps. Hitherto, in his town, the relations between the corporation and the gas company had been very agreeable, and the latter were unwilling to disturb them by adopting street governors. But now that the works had passed into the hands of the corporation they would no doubt be introduced, and probably the leakage might be reduced from 14 to 10 per cent.

Mr. WATSON (Sydenham) was sure that every one present had listened with much interest to the papers read. The subjects discussed involved matters of no little importance to gas companies, and for himself he felt confident that he stood second to none in the room for the efforts he had made in years past to effect a reduction in leakage. In the company which he had the honour to represent (the Crystal Palace District Gas Company) the leakage was under 9 per cent., which was certainly to be considered a satisfactory state of things. He thought they were perhaps too apt to underrate the importance of little things in connexion with this question, and yet the reduction of leakage depended very much upon them. They knew all about the value of properly laid services, the employment of competent men, the tarring of the pipes, &c., but he was afraid sufficient attention was not always given to the bi-quarterly inspection of meters. If this were done, and a little more time was bestowed upon street regulators and public lamps, a serious source of unaccounted-for gas would be discovered, and might be effectually dealt with.

Mr. DOUGLAS (Waltham Cross) said that having had considerable experience in street-mains he did not believe very much in the supposed loss from condensation. He had tried it for a year or two on a 20-inch main, and the condensation was by no means great. The temperature of the gas was 45° when it

entered, and it continued pretty much at that in the pipe. He never found it at less than 40°. For his own part he did not think there was very much condensation after manufacture. He had filled a gasholder and let it stand for a week without any great alteration. People sometimes said that the gas in the upper part was not so good, and that the holders ought to be emptied frequently. All he could say was he had never found it so. He believed the question of pressure was a very great point, and that there should never be more than two inches on the works. Whenever that was insufficient the pipes should be made larger. He did not attach much value to the use of street governors. Have the mains large enough, and the largest mains next the works, and there would be no trouble with them. Small pipes were the very ruination of a company. As to the inspection of meters, his experience in London had shown him the necessity and importance of this matter, and that it was a profit to a company to put in large meters. At one time he was connected with a company—a small company with about 1000 meters—and he advised the directors to put in new meters. As they were not very willing to do so he told them that if they would give him all the gas paid for over and above that which the existing meters registered for two years, he would pay for the new meters himself. They agreed to do so, but at the end of the first year they said they would rather not keep to their bargain. As to service-pipes, having laid miles of them in London, he did not believe much in leakage from that source. He had never found it very much, but he quite concurred in the remark just made as to the policy of taking up old mains when new mains were laid. Some people were apt to steal gas, especially when there were competing companies, and one way to prevent that was to take up old mains.

Mr. Jabez Church said he thought the first element to be considered in this question was to have their mains properly constructed and laid, for without that, whatever else was done, they could not effect the object desired. In one particular, which had come under his notice, he thought mains were often laid not sufficiently deep. No main, however small, should, in his opinion, be laid at less than 18 inches from the surface of the road to the top of the pipe as a minimum; for this reason—when they got down two feet the range of temperature to which the pipes were subject in this country did not affect the metal, consequently there was an avoidance of expansion and contraction, so that whether they used turned and bored, or any other kind of joints, there would be a less amount of leakage. An excellent plan to be adopted was to test the mains, as laid down, at five times the pressure under which they would ordinarily be worked. The slightest pin-hole would be detected in that way. Care in this respect had an excellent effect upon the workmen in making them more vigilant. Main-laying involved a great deal of care and attention, and even men who were frequently employed at it often made inferior work. Another element for consideration was the size of the pipes. No doubt, in the case of small pipes, when the velocity was increased in passing large quantities of gas through them, there was considerable loss, and condensation came into play more than under any other circumstance. But they could not dismiss from their minds the conviction that with every consideration and most careful inspection there was an enormous amount of waste from the mains and services. It was only necessary to see a street opened in London to be convinced of this, for often it would be found that the ground was perfectly blackened with the gas that had escaped from the pipes. In many cases the gas permeated through the molecules of the iron pipes. He thought great attention ought to be paid to service-pipes, because, after all, a considerable amount of leakage did arise from them. If the service-pipes were well looked after a great source of leakage would be discovered, and if a careful revision was undertaken the leakage would sink to a minimum. In laying a main, as a rule he considered that 9 or 10 per cent. in modern works should be the normal amount of leakage; where it exceeded this he should pronounce the work as unskilfully performed. And this question of leakage was one of great importance to gas companies. In going to Parliament for an increase of capital, or a variety of purposes, this question was now-a-days fully discussed, and woe be to the company who neglected it, for if they showed a large amount of leakage it inevitably affected their interests so far as their parliamentary powers were concerned. In every point of view, therefore, it behoved gas engineers in construction and gas managers in management to give to this question all the care which it certainly deserved.

Mr. G. W. Stevenson ventured to think that it would be a very happy day for gas companies when their experience corresponded with the friend referred to at Manchester, and they had no leakage and no unaccounted-for gas. It was a common saying that the profits of a gas company were made or lost in the retort-house. Others things being equal, that was true. There the raw material was turned into the manufactured article; but having got the manufactured article, the company wanted to deliver it all, or as nearly all as possible, to the consumer through his meter. The question was how that could best be done. He thought Mr. Emmerson had really touched all the points that were to be considered in the matter. First of all came large mains—well-laid mains—then good services and good meters; a well-considered system of distribution, and a careful supervision of the public lamps. All these things were to be taken into account, and when that was done no doubt the leakage in towns generally, and even in very irregularly built towns, might be brought within 10 per cent. His own experience went to this point. In 1856 he went to Halifax to take charge of the gas-works for the corporation of that town. The unaccounted-for gas was then close upon 30 per cent. He took the question of the distribution in hand at once, before remodelling the works, and within two years (although there was a variation of level within the limits of supply of over 600 feet) he brought down the leakage under 10 per cent. This was effected simply by the introduction of street governors. Mr. Douglas in his remarks intimated that he did not like them, but he (Mr. Stevenson) found them absolutely necessary in Halifax, for wet meters were in use in that town, and they used to blow the water out of the meters. He, therefore, laid a new system of pipeage, and introduced street governors, and nowhere in the town (with 60 or 80 miles of mains) was there a pressure of less than 1½ inch, or more than 2½ inches. What was the consequence? The corporation saved £3000 a year in leakage, and the leakage was under 10 per cent. Since then the district supplied had been very much extended, and a great many miles of new main laid, but he believed the leakage at the present time was under 9 per cent. In 1866 it was his ill-luck to oppose a company in Parliament whose leakage was what was called a normal leakage—about 14 per cent. The engineer of the company was asked in cross-examination, "Cannot you undertake to bring your leakage down to what Mr. Stevenson says it ought to be—viz., under 10 per cent.?" He said it might. He thought he was working well, but said it might. That company were in Parliament this year, and the unaccounted-for gas, through good management and by taking advantage of the summer season to district the town and supply gas through a meter to certain districts, and thus seeing where the unaccounted-for gas went to, had been brought down to between 8 and 9 per cent., almost exactly the quantity which Mr. Watson had given as the rate of his leakage;—and an admirably managed work was that of the Crystal Palace District Company. He would say to gas managers, "Don't begin with a small main and go up to a large one. Begin at the works with a proper sized main for the supply of your district. If one will not do, and if you have districts lying far apart, take as many mains out of your works as you require in the directions needed, but do see that they are large enough to do their work. And if you have a rising district, control the pressure by street governors, and in that way keep the gas back for the low districts, and give a fresh initial pressure for the upper districts. In that way keep down your pressure and your leakage." He was sure that next to making money in the retort-house there was money to be made in the streets. The unaccounted-for gas was a most serious thing with many companies. It was well known that the largest company in the world had a leakage of over 750 million cubic feet per annum, which represented no less than £60,000 a year. There was an income for a gas company! If the leakage of the Chartered Gas Company were reduced to 10 per cent., it would give them 4 or 5 per cent. dividend upon their share capital, and they might do it as easily as any of the members present were doing it in their works. Therefore, he repeated it, this was a most important question, and one which ought strenuously to be urged upon the attention of all gas managers. If they wished to increase the dividends for their shareholders and put themselves in a position to be able to reduce the price of gas to consumers, let them first of all look to their leakage.

Mr. Peebles (Edinburgh) would have gas managers adopt as a motto, "Beware of the Steam Roller," for it would be found after the roller was

in use some time there would be an increased amount of leakage in the streets.

Mr. WATSON mentioned a case in which a 20-ton roller had been in use for a week, during which 30 or 40 pipes were broken by it. Each of these pipes was not more than 12 inches from the surface.

Mr. BARRETT (Accrington) thought one point which deserved notice was this—when wet meters were very largely used there should be frequent inspection and proper attention to the watering of those meters. He had had considerable experience with regard to this matter, having had four works under his care. He undertook the charge of works, on one occasion, which the proprietors were about to sell, as they could not make them answer. Believing they might be made to pay 7 per cent. the first year, he accepted the management, agreeing to receive for his professional assistance all the profits beyond that amount. He found the inspector in that place not worth twopence, for it had been supposed that any man was capable of undertaking that office. By careful management he (Mr. Barrett) was able to make the works pay 10 per cent. at the end of 12 months. He held it to be essential that all inspectors, especially in the case where wet meters were in use, should have some mechanical knowledge as to the construction of those meters, or it was impossible for them to deal with them. It was no use for managers to exert their energies to get all the gas possible out of the coals, if a large quantity of this gas was to pass through the consumers meters unregistered.

Mr. TALLENTIRE (Lisburn) said some facts appeared to him to have been overlooked in the paper and in the discussion. No one had referred to the distance the gas had to travel, nor the pressure that must be maintained. In his case he had to supply mills at a distance of two miles and 2½ miles from the works, and from the time those mills lighted up till they ceased burning he was under the necessity of keeping up a 3-inch pressure on the mains. Two of these mills had gasholders of their own, and being situated so much below the gas-works, the 3-inch pressure was not sufficient, and they drew from him to fill their holders day and night; consequently his unaccounted-for gas for the last 12 months had been over 20 per cent. This pressure was kept on from the latter end of October to the middle of March. He had tested the length of the main at every two or three yards, and could find no leakage. If any one could show him how to reduce his unaccounted-for gas he would be glad.

Mr. BROADHEAD (Grimsby) said he had frequently read that the lowest estimate for unaccounted-for gas was 10 per cent., and the highest 20 to 30, and when he heard Mr. Watson say his leakage was about 8 per cent. he thought he must keep still. But after hearing the last speaker state that his leakage was 20 per cent., he felt he might venture a word. In his own case the leakage had been as low as 11; it had been as high as 16, and now it was 14 per cent. When it was at 11 per cent. he was making only 11 millions per annum, now he was making 50 millions. He had 2300 consumers and 300 public lamps to supply; 20 miles of mains from 12 inches down to 3 inches, and two-thirds of the soil in which they were laid was pretty good clay, while the other third was entirely sand from the sea, and of a character which quickly destroyed the services. After what he had heard, he should be inclined to put them in black coffins like Mr. Warner's. Having extensive docks to supply, which yielded a rental of £1400 a year, and where there was a good deal of night work carried on, he was required to keep up the pressure till 10 or 11 o'clock. In supplying the public lights he professed to give 5 cubic feet per lamp per hour; so that, perhaps, under all circumstances, his 14 per cent. unaccounted-for gas might be considered not an unreasonable thing.

Mr. DAVIS (Hereford) remarked that a good deal had been said with regard to leakage from mains and service-pipes. There could be no question, he thought, that this was a source of the evil, but by the improvements made of late years a great deal of this had been done away with. But there was one direction in which the unaccounted-for gas might be searched for successfully. In his city they had for many years been lighting the public lamps, numbering in all about 400, 91 of which were kept burning from sunset to sunrise, and the remaining portion only till midnight during the greater part of the year. Two years ago the corporation made an alteration in the lighting arrangements, and instead of lighting the last-named lamps till 12 o'clock only, they lighted the whole of the lamps all night, with the exception of June and July. The unac-

counted-for gas formerly was rather over 18 per cent., but as the result of the first year's working of the new arrangement—without making any improvements in the mains, without laying any new services, or doing anything by which the previous loss might be expected to be reduced, with the exception of renewing a portion of the meters when the Sales of Gas Act came into force—the unaccounted-for gas was now brought down to a little over 11 per cent. There was no doubt in his mind that previously the lamps up to 11 or 12 o'clock at night were burning 7, 8, 10, and even 11 feet each per hour. He was perfectly well aware of the fact, and was repeatedly calling the attention of the directors to it, and pointing out the saving which would arise from affixing a governor to each lamp, but as the company were paying their full dividend—and a good dividend, too, of something like 20 per cent.—they did not see the necessity for expending £150 in altering their lamps. The corporation, of course, could not see the necessity. There was a proposition that if the Lighting Committee would bear one-half of the expense the company would pay the other, but this was never carried out. The works had now passed into the hands of the corporation, and at the last meeting of the council, he (Mr. Davis) submitted a proposition, and the Lighting Committee were going to put governors to the lamps without making a charge upon the Gas Managing Committee for the same. When this was carried out he had no doubt that the unaccounted-for gas would be reduced to 10 per cent., and even less.

Mr. ELDRIDGE (Richmond) said he should like to ask Mr. Watson and Mr. Stevenson how they calculated the quantity of gas supplied to the public lamps—whether by meter or as a mere estimate. A great deal turned upon this, and he believed that the difference of anaccounted-for gas frequently arose in this way.

Mr. WATSON said the company used Sugg's regulators, for which they paid a certain price, and the manufacturer guaranteed their proper working order at 5 feet per hour.

The PRESIDENT: How do you know that it is 5 feet and not less or more?

Mr. WATSON: I take it for granted it is quite 5 feet, but I believe it is nearer 6.

The PRESIDENT: I think you may take that as a general rule.

Mr. STEVENSON: I am in a better position, and I shall have to name the company. It is the Brighton and Hove Company—one of the best managed in the kingdom. They supply gas to the public lamps by average meter registration, and the unaccounted-for gas, which was 14 odd per cent. in 1866, is now less than 9 per cent. At Halifax there is no regulator and no meter, and they burn 5, 6, 7, or 8 feet—anything you like.

Mr. CHURCH said, as he had made the same statement as to leakage, he might be also allowed to answer the question. He took it as a matter of fact that if a gas company contracted with a corporation or local authority to give them 5 feet per hour, they had no business to give them 6; but he looked upon unaccounted-for gas as being the difference between the gas registered at the station-meter and the amount brought into the revenue account. Therefore in estimating the unaccounted-for gas, he took the quantity at the station-meter, the quantity registered at the consumers meters and brought to book, and then the amount received for the public lamps less the charge for lighting, cleaning, &c., and saw how much that represented. He believe that was the true way of arriving at the correct commercial result.

The PRESIDENT: Do you mean to say you take the quantity consumed by the public lamps at 5 feet?

Mr. CHURCH: No; I take the quantity paid for, deducting the cost of lighting, &c., and I say the balance represents so many thousand feet at the price at which the gas is supplied.

Mr. METHVEN said at Sudbury, which was supplied from works belonging to him, he had adopted the average meter system. He also used Sugg's regulators, adapted for a consumption of 4 feet per hour. His manager told him that the actual consumption was a little more than 4½ feet per hour.

Mr. G. ANDERSON said he had heard so much that was so generally known that he felt he had gained little information on the subject after all the conversation that had taken place. The paper read by Mr. Emmerson related to a subject of the first importance, and he appeared to have said almost all that could be said about it, but all the subsequent talk about per centages was what the Americans called "bosh." And he would give his proof of it. Their

friend from Leeds—or rather the friend who always wanted to be going there—stated that a few years ago his unaccounted-for gas was 14 per cent., and that now it had got down to 11 per cent. But what were the facts? When his leakage was 14 per cent. he was making 11 million feet of gas, so that his leakage amounted to 1,540,000 per annum; now that he was making 50 millions of gas his leakage was only 11 per cent. But what was 11 per cent.? 5,500,000; *ergo*, he was losing about four times as much gas now as he used to do, notwithstanding the per centage was smaller. Now, he called attention to this matter because he was entirely opposed on principle to a course which was very much adopted in the present day. An unfortunate company went to Parliament, and up started some one immediately to state how much better he could carry on their business than the company had done. It was utterly unfair to the company to talk about what they ought to have done, as though they had been supplying a brand new district with new works on the most improved principles. This was the basis on which all such high-flown calculations were based, and he contended that it was impossible for those who had charge of works 40 or 50 years old, in towns where, perhaps, other works had been swallowed up and absorbed, so that no one knew exactly how and where the mains were laid, to carry on their operations with these theoretical per centages. What would be bad working with 10 per cent. leakage in one case would be good working and consistent with efficient management at 20 per cent. in another. He was as much interested in attaining a low rate as any one, because he was the lessee of many works; but, as a matter of fact, he knew that the leakage in some was double what it was in others. He did his best to district his mains, put on meters, check the consumption of the public lamps, and take every other means indicated. Yet, notwithstanding all, he found it impossible in some places to reduce the leakage to what he should like it to be. Some of the members of the association had to supply mining districts where there were miles of galleries stretched below them, and where, from constant subsidences, mains were always leaking. Others were supplying close to the sea, where there was nothing solid, and others in manufacturing districts, where soda and acids were made, which percolated the soil, oxidized the pipes, and soon made them leaky. In all cases circumstances must be taken into account, and he protested against the general statements being made about per centages as though any fixed rule could be adopted. It was all nonsense.

Mr. Martin (Ormskirk) said in the last three years his consumption had decreased materially, and so also had his unaccounted-for gas. He attributed this chiefly to two causes, one was the laying of larger mains, and the other the putting down of three separate mains from the works with three separate governors. Although his delivery was small—under 12 millions—he thought it expedient to have three governors, and he attributed the smallness of his leakage very much to that fact. Another remedial measure was the watering of the meters oftener than before. While the sale of gas had decreased in his town, and the capital had been augmented, the balance of revenue had increased.

The President: What is your leakage now?

Mr. Martin: 7½ per cent.; it was 35 per cent. before.

Mr. Tallentire said he had observed from the remarks made, that there was a great difference in the mode of taking the unaccounted-for gas. He lighted by average meter indication, and took the consumption at the meters, and what was paid for public lights; other gentlemen did not do so.

The President remarked that there were, no doubt, various ways in which leakage was calculated, but by a comparison of the facts stated, the results in all cases could be ascertained. The general mode was to take the quantity of gas registered at the station-meter, and from that deduct the quantity used on the works; the quantity registered at the consumers meters, and the quantity consumed by the public lamps (which he always calculated as 4000 hours, at 5 feet per hour each).

Mr. Thomas (Alton) thought a portion of unaccounted-for gas might be traced to the settling of pipes. Sometimes in laying mains the trenches were dug too deep in parts, and stones were put under the pipes, which when the ground was rammed in were sure to sink. Other sources of evil were that meters were sometimes not fixed level, and dry meters not tested often enough.

Mr. Gibb traced a good deal of the evil to not having a proper register of

services and an acquaintance with the soil in which they were laid. Defective services were a great source of loss.

Mr. WARNER (South Shields) said if this discussion had taken place some few years since the one great and important question debated would have been that of meters. It would have been a battle of the Wets and the Drys. He was very happy to say that that had entirely passed away, because it convinced him that managers generally were thoroughly assured that in well-constructed meters, whether wet or dry, they had now a perfect measure of the gas they supplied. To his mind this was a very pleasing state of things. With regard to the general discussion, while he regarded it as upon the whole satisfactory, he thought there had been some little mistakes. On the question of mains, new ones had been spoken of, and the manner of laying, and there was evidently a tendency to treat a town as a new district to be lighted instead of taking it as lighted, and to be dealt with accordingly as a whole. As to leaky mains, only during the previous week he was putting down a new 10-inch main. He cut off a portion of the district, and before the new main was connected he had the district tried. They were registering through a small meter for the purpose with 15-10ths pressure, and he found they were losing some 90 feet of gas an hour. He then had several streets cut off, and brought down the loss to 8 or 10 feet. He had the services relaid, but it seemed to make no difference. He then had the main stripped, and found that two of the joints had drawn. The loss was then about 1 foot per minute on the section under test, and this was brought down to 1-10th. As to services, he believed lead was not the material for this purpose. The iron tubing boxed in with tar and sawdust, as in the model before the meeting, aptly described by Mr. Broadhead as his (Mr. Warner's) coffin, was the only effectual method of preventing leaky services. Unaccounted-for gas, however, did not arise from either meter, main, or service alone, or the whole together, but from the want of a more thorough system and much greater attention than had been paid to the whole of this important matter of distribution.

Mr. EMMERSON briefly replied, and expressed his satisfaction at the practical character of the discussion which had taken place on his paper.

On the motion of the PRESIDENT, thanks were voted to Mr. Warner and to Mr. Emmerson for their papers.

Mr. GREEN (Dartford) read the following paper on

STOPPAGES IN ASCENSION-PIPES.

With your kind permission, I will endeavour, without encroaching upon your valuable time in a lengthy preamble, to place before you what appears to me a remedy that will materially assist, if not entirely prevent, the trouble and annoyance of choked ascension-pipes.

Most of us are too well acquainted with the demand upon our time and patience, besides the nuisance and cost frequently occasioned by what is called by our stokers "blocked pipes." Many and various have been the suggestions, and even patents brought to bear upon this important matter, with what effect, so far as practically removing the evil, you can best judge. It is not for me to presume showing you over ground well known to you all; but from what I have ascertained at the small works I have charge of, and from the printed reports that have come to my notice, I am constrained to think we have not been looking quite in the right direction to find a remedy—viz., at the size of ascension-pipes, their heat, &c. From what has presented itself to me latterly, I think with the gentleman who spoke upon the subject at our last meeting—that the pipes might be twice the ordinary size, and he may have said as cool as you please. It would then, even under these circumstances, only be a question of time.

Now it is well known that to carbonize with high heats we are sure of having some choked ascension-pipes, and that it never occurs with low heats without there is some defect in the pipe itself. This plainly points out that the heat of the retorts is the chief contributor to stopped pipes. Turning this matter over in my mind, I thought if it were possible to intercept the flow from the retort before it gained access to the ascension-pipe, probably some of the substance that caused this intolerable nuisance might be arrested, and an opportunity afforded of scrutinizing this our common enemy, and see what it was really made of. With this view, I constructed a

guard with shelves, and placed it into the mouthpiece of a retort after it had been charged with the usual quantity of Newcastle coal. This retort was the best heat of any in the set, and the ascension-pipe was constantly choking up. It being necessary to remove the lid, at least twice during the process of carbonising an ordinary charge to clear the obstruction. The lid of the retort was then secured, and instructions given that if anything went wrong with that particular retort, the stoker should come to me. I saw no more of the retort or the stoker until the usual time of charging had come again, when I was pleased to know that it had not been necessary to remove the lid during the whole time that charge had been working off. The lid was then removed, and the guard withdrawn, upon the shelves of which was deposited something which I now show to you, and which would, no doubt, have choked the ascension-pipe. The same guard is now regularly placed into that retort, with the same beneficial results. It was made of common plate-iron, about ½-inch thick, with a loop upon the front to admit the point of an ordinary small rake, by which it can be quickly taken out or replaced when required.

Shortly after this, in another set, we had a pipe leading from a very hot retort, so choked that nothing could be got through. The pipe was therefore disconnected and another put in its place. It was fixed and ready for work before the man could complete the guard; but so convinced was I that *this pipe* would choke up like the previous one without it was guarded, that I had the guard placed into the retort unfinished (without the shelves). Nothing more has been done to that guard, and the ascension-pipe has not been choked since; in fact, with our guards, we are now the masters instead of slaves to ascension-pipes as heretofore. But, as prevention is better than cure, I would advise the use of such a guard before the pipes become choked. Since then other guards have been constructed similar to that in sketch No. 3; being convinced that the previous ones were a step in the right direction, and they have stood the severest tests possible.

And now, gentlemen, after the remedy has been pointed out to you, the cause of choked ascension-pipes must be left to your individual opinions, which I do not pretend to combat here. My opinion, however, is that they are produced in this way. The higher we get the heats in the retorts, the more cessible become particles of disintegrated carbon and other dry substances which are continually being made and drop from the inside of the retort, and these are the very particles that have been caught upon the shelves of my guard. They are swept off, mingle with, and are carried along by the crude gas, which is being rapidly produced by great heat from the coal in the retort, and meeting the tar that slowly flows down the sides of the ascension-pipe, when near the entrance, becomes so thickened with this continuous process, that a substance is quickly formed which ultimately chokes the pipe.

I think there may be other advantages gained by using this guard. Frequent complaints are made of accumulations of a thick substance forming in hydraulic maines, which, in spite of many contrivances, adds to the pressure upon the retorts. Probably this is caused by a quantity of minute particles of finely divided carbon or other substances being driven by excessive heat from the retort, and from their lightness succeed in reaching the dip-pipe, and then becoming deposited in the hydraulic main, are the cause of increased pressure through the opposition they offer to displacement.

Other ideas have presented themselves, which induce me to attach a future importance to the guard I have had the honour to explain; but as time and other circumstances have not permitted me to complete my investigation, I prefer withholding the result until I shall be in a position to place them before you with greater confidence.

The PRESIDENT asked Mr. Green how long his contrivance had been in use.

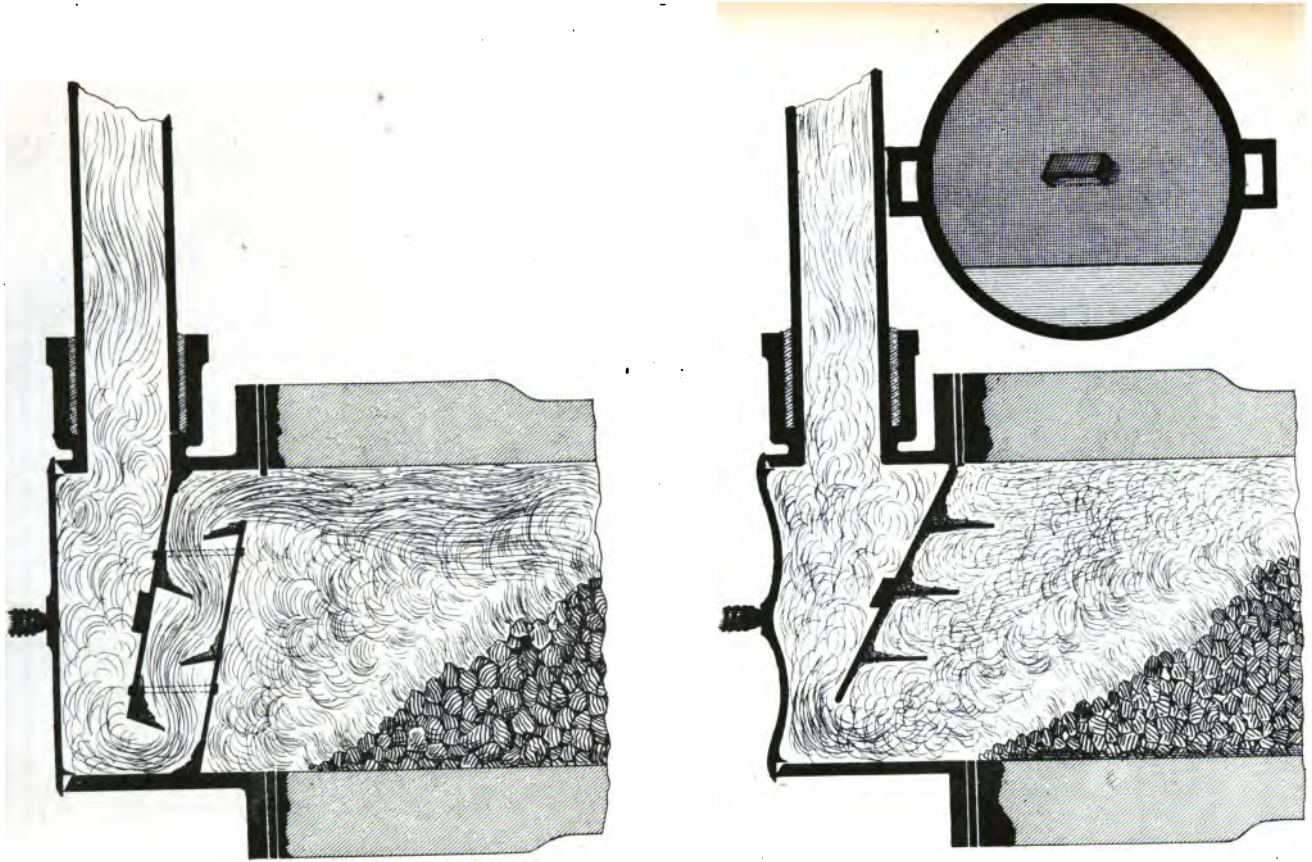
Mr. GREEN: About two months.

The PRESIDENT: You would be worth your weight in gold if you could effectually get rid of stopped pipes.

The SECRETARY read the following paper by Mr. W. Parlby (Aylesbury) on

STOPPAGES IN ASCENSION-PIPES.

Among the many operations almost incessantly going on in a gas-works, it is not to be wondered at that here and there difficulties arise which require



GREEN'S APPARATUS

for preventing Stoppages in Ascension Pipes.

Whiteman & Bass, *Litho to the Queen*, 236, Holborn, London.

UNIV. OF MICH.

much ingenuity and skill to surmount. Of these difficulties, perhaps none have been more frequent in their occurrence and perplexing in their character than the stoppage of ascension-pipes. This evil has existed from the early days of gas manufacture, and, notwithstanding the attention which engineers have so long devoted with the view of removing it, there is as yet no generally acknowledged plan whereby such stoppages may be prevented.

Various suggestions, more or less valuable, have from time to time been made, but the question still remains open for solution—How can stoppages in the ascension-pipes of gas-retorts be prevented? Desirous of settling this question, our committee have again, in their syllabus of subjects, brought the matter under the notice of the members; and, in sympathy with that desire, the writer has attempted to put together a few practical suggestions, which, with the discussion of the meeting, it is hoped will prove a means of clearing up the difficulty. I would, however, observe that a very useful and valuable paper on this subject was read before the association in Dublin in 1871, by Mr. Somerville, on which occasion it was not my privilege to be present. The only reason I have for bringing the subject again before the members is the importance which we all attach to it.

That the question may be systematically and practically solved, we cannot proceed in a better way than by inquiring—

Firstly—Whence such stoppages arise, and

Secondly—Ascertain how they may be avoided.

Firstly—Whence such stoppages arise. Chemical science has demonstrated that the formation of carbon in the retorts is occasioned by the very high temperature necessary to effect the proper carbonization of the coal, under which circumstances a portion of the evolved hydrocarbons is decomposed. The gases given off in the distillation of the coal become further acted upon by the greatly reduced temperature of the ascension-pipes, in the interior of which, as we all know (after the pipes have been in use a short time), a carbonaceous deposit, somewhat analogous to pitch, is frequently to be found. To this settlement in the pipes is attributed the cause of stoppages.

If the gas could always with safety be drawn away immediately it is generated from the coal, the formation of carbon in the retorts would probably never trouble us; but, as this is generally impracticable in ordinary working with the apparatus now in vogue, a portion of the gas necessarily undergoes decomposition, notwithstanding the benefits realized by the exhauster. This carbonaceous settlement in the pipes is a somewhat different modification to that formed in the retort, and may be considered as partly the result of chemical and partly that of mechanical action to which the gases are exposed at varying temperatures. To what circumstances, then, are to be traced the stoppages of ascension-pipes.

1. The heat given out from the coke left behind after the gas has been generated from the charge of coal in the retort converts the tarry deposit in the pipes into a substance very much resembling pitch, which, in the course of time, prevents the passage of the gas. This fact is observable if a setting of retorts is allowed to lie idle beyond the time necessary to work off the charge. The tar accumulated on the sides of the ascension-pipes becoming exposed to the higher temperature of the incandescent coke is deprived of its more volatile constituents, leaving a dense spongy incrustation around the lower part of the pipes and the top of the mouth-pieces, which, unless completely removed before the retorts are recharged, will speedily choke up the pipes.

2. A large seal of the dip-pipe acts exceedingly prejudicially to the flow of the gas, fosters the formation of carbonaceous matter in the ascension-pipes and retorts, thereby considerably diminishing both the quantity and quality of the gas produced.

3. Any flaw or defect in the casting of the pipes, and any impediment arising from irregularities in the joints in the interior, present a means at once favourable for the formation and settlement of deposit. This there can be no doubt is an important point in the question of stoppages.

4. Every facility for the choking of the pipes is afforded when their capacity and the hydraulic main is inadequate for carrying off the gas.

These four reasons explanatory of the occasion of stoppages have not hurriedly been arrived at, but are the result of a careful and minute investigation. They may not embrace all that is associated with the cause or causes

of stoppages, but they reduce the question to a more definite form, and bring its solution within the reach of every gas manager.

We have now, *secondly, to ascertain how such stoppages may be avoided.*

It will be clear it is of the greatest importance that the outlet of the mouthpiece should be sufficiently large as to permit of the unobstructed passage of the gas during the carbonization of the coal; otherwise, as we have before shown, the crude gaseous products emitted during the distillation will remain exposed to the action of the heat, and by their partial decomposition will leave their incrustations of carbon or pitch around the orifice of the mouthpiece, and ultimately stop up the gas way.

It is also important that the ascension, bridge, and dip-pipes be large enough to carry off without obstruction the products of distillation, which for retorts of the ordinary size should certainly not be less than five or six inches in diameter internal measurement, and with as few angles and joints as practicable.

Particular care should also be taken in the moulding and casting of the pipes and in the making of the joints so as to avoid irregular surfaces in the interior.

Another important point to be observed in order to secure the ascension-pipes from gathering deposit is the employment of a proper seal for the dip-pipe in the hydraulic main. If it exceeds ¾ of an inch in depth, there is but little doubt that the gaseous products of the coal will continue too long in contact with the pipe, and produce a tarry deposit therein. The manufacturer will also be deprived of a large quantity of the richer hydrocarbons, whilst the action of the retorts and pipes is seriously impeded.

Special attention should also be paid to the size of the hydraulic main, and the outlet for the gas and liquid, and the capacity should be such as to afford the easy passage thereof.

From these considerations it will appear that the stoppage of ascension-pipes is fostered under various circumstances, sometimes by a defective mouthpiece, sometimes by small, irregular pipes and bad joints, sometimes by a contracted main and large seal of the dip-pipe.

In studying to avoid stoppages, we cannot be too careful in the attention required by these points of detail to which I have adverted. The application, however, of improvements in these respects, though absolutely essential if we would obtain the most satisfactory results, will not furnish us with the means whereby stoppages may be altogether avoided. The secret of success, I believe to be in the hands of the stokers, providing there exists suitable and well-arranged apparatus. Let them be required to attend to the following instructions, viz. :—

1. The temperature of the retorts to be maintained at a uniform degree—say a good white heat.

2. The mouthpice to be kept clear of carbonaceous and tarry matter as much as possible.

3. Whenever a charge of coals is worked off, and the retorts are not wanted for immediate use, let all the lids be slightly unfastened, or the heat from the coke will congeal the tar in the ascension-pipe, converting it into pitch, thereby preventing the passage of the gas.

4. The hottest retorts to be charged heavier proportionately to the others, that the charges may be worked off in the same length of time.

Since writing the above, the writer has had his attention directed to an improvement recently introduced by Mr. Malam, of the Dumfries Gas-Works, by which the choking of the ascension-pipes is said to be prevented. The improvement consists in causing a small stream of water to enter the ascension-pipe at the top, which, being delivered in a thin spray, diffuses itself in the interior of the pipe, keeping it cool, and preventing deposit. An account of this improvement is given in the JOURNAL OF GAS LIGHTING, of April 13, 1873.

In conclusion, permit me to add that it is with some degree of reluctance I have been induced to lay these observations before you, but in reliance upon that forbearance and co-operation which the members on every occasion have accorded the writers of papers, I leave them in your hands.

The PRESIDENT said he could not conceive anything more annoying than the visit of a plague of stopped pipes to a manager. Nothing could be more depressing to him, and nothing more serious for the works. In the first place, it wearied the men, who had to use sledge hammers to clear the pipes; it destroyed the retorts, for they would not last half their time. Of course, as was to be expected, any general evil such as stopped pipes was sure to have many remedies suggested; but, after all, he was inclined to think it depended

very largely upon the quantity and kind of coal used. He remembered very well that when he entered into the service of the Chartered Company their dip-pipes were only 2½ inches. He did not know what would be thought of an engineer now-a-days who had only 2½ inches. He remembered that he altered the pipes by putting in pieces of tin just underneath the flange upon the hydraulic main, by which means he increased the 2½ inches by the thickness of the cast iron; but this he noticed, that when they were using a particular kind of coal, with ordinary care on the part of the stokers, they had no stopped pipes. The moment they changed to another kind of coal the plague was upon them. They tried water in the mouthpiece, putting in small dishes of water, so that it might evaporate and so the steam loosen and prevent the filling up of the pipes; but the end of it all was that whenever they used this coal there was sure to be stopped pipes. All he could do was to say to the men, "Be particularly careful in augering the retort-pipes, and keep them thoroughly clear every time the retorts are drawn." He must confess that the suggestion thrown out by Mr. Green appeared to him a very reasonable one. Stopped pipes occurred through the volatilization of dry particles of carbon, which seemed to sublime up and settle in the pipes, and it seemed to him very likely that the screen which Mr. Green proposed to put in might prevent these dry particles ascending. If the contrivance did succeed, it would be a most valuable invention, and prove of the greatest consequence to gas companies and managers. It was for that reason he asked Mr. Green what experience he had had with it. One would like to hear that it had been in use two years, and not two months only. It certainly bade fair to be of some service.

Mr. CHURCH asked whether the screen was the whole width of the retort, and how it was fastened in.

Mr. GREEN replied by producing a model of a retort mouthpiece, fitted with screens, which showed them fitting the sides and top of the mouthpiece, but having a space at bottom to allow the gas to pass through on its way to the ascension-pipe.

The PRESIDENT said it was simply put into the retort between the coals and the ascension-pipe.

Mr. DOUGLAS said for many years he had not had stopped pipes, because he made his ascension-pipe six inches. But with some kinds of coal he believed stoppages would occur in any pipes. He had an idea that the invention just introduced to their notice might answer the purpose intended.

Mr. BARTHOLOMEW (Glasgow) asked what the screen was composed of.

The PRESIDENT: Sheet iron.

Mr. BARTHOLOMEW doubted, if that were the case, whether it would continue long in shape.

The PRESIDENT said it was placed in the cool of the retort—merely in the mouthpiece.

Mr. BARTHOLOMEW still expressed doubt whether it would maintain its form.

Mr. GREEN: The one we have used for two months keeps its form, and is not bent or out of shape in any way.

Mr. BARTHOLOMEW: It will depend very much upon the temperature of the retort. In my experience I have never had stopped pipes except with high heats.

Mr. WARNER: May I ask whether, when using the coals to which the president referred, where stopped pipes occurred, greater heats might not have been used, or whether, in his opinion, the evil arose entirely from the coal.

The PRESIDENT: The experience I have is this, that with retorts at the same temperature, worked identically in the same way, we never had stopped pipes while using one kind, and that with the same retorts, at the same temperature, with the other coal, we invariably had them.

Mr. PATERSON (Warrington) said he thought the chairman had indicated clearly the direction in which to look. There was no doubt at all that, under the influence of temperature, coals were very differently affected. He had himself frequently found no difficulty with one kind, while with another description, at the same temperature, he had suffered from the evil complained of. To meet this evil he had enlarged the diameter of his pipes, and had put them in from 6 up to 9 inches, and even in this largest size he had had stoppages. He thought the design submitted by Mr. Green might prove beneficial.

Mr. EMMERSON said the subject of stopped pipes was a great difficulty to him last winter. It had been remarked that increasing the bore of the pipe would be some mitigation of the evil; but he might state that at the last

works he had in charge, which were smaller than his present works, he never knew what a choked pipe was. At present he was scarcely 24 hours without one. It struck him that it was more a question of temperature than size of pipe, and that if something like a tuyere coil could be jacketed in the ascension-pipe, and a continuous stream of water made to trickle down it, they might get over the evil.

Mr. WATSON said the best plan was to keep the ascension-pipes as far away from the brickwork as possible. If they were kept cool there would be no difficulty with stopped pipes. He found that whenever he used coal which had been kept out of doors two or three months there was an immediate tendency to stoppages.

The thanks of the association having been voted to Mr. Green and Mr. Parlby, the sitting closed.

At seven o'clock the members and their friends attended a *conversazione* in the University Industrial Museum, to which they were invited by a committee representing a number of gentlemen whose names will be found below,* and who are connected with the coal trade, the supply of fire-clay goods, gas-works apparatus, meters, &c.

At eight o'clock the following lecture was delivered in the lecture-hall of the same building :—

ON THE PHYSICO-CHEMICAL PROPERTIES OF GASES.

By Dr. STEVENSON MACADAM, F.R.S.E., F.C.S., &c.

Ladies and Gentlemen,—When the committee of the Association of Gas Managers asked me to lecture this evening, I thought it would be better to take up a subject which might not be regarded as strictly within the beaten track of other discourses delivered by previous lecturers before the association. Consequently, as many questions connected with the manufacture and purification of coal gas, and likewise the methods of burning it with the greatest possible efficiency, had been fully discussed at meetings in the South by Dr. Letheby and Dr. Odling, as also at previous meetings in the North by Dr. Wallace and myself, it appeared to me desirable that we should to-night take up some of those peculiar properties of gases which may be regarded as bordering upon pure chemistry and pure physics—in other words, that we should take up some of those subjects which may be spoken of under the general term of the physico-chemical relations of gases—rather, I may say,

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* The following are the firms and gentlemen by whom the entertainments were provided :—Messrs. R. Laidlaw and Sons, Glasgow and Edinburgh; The Haywood Gas Coal Company; The Nitshill and Lesmahagow Coal Company; James M'Kelvie, Edinburgh; William Fraser, Inverkeithing; James Davidson, Newbattle Colliery; Henry Balfour and Co., Durie Foundry, Leven; Shotts Iron Company; J. and W. Romans, Forth Street, Edinburgh; George Wilson and Co., Kinnal Iron-Works; W. and B. Cowan, Edinburgh; Lochgelly Iron Company; James Milne and Son, Edinburgh; Pirnie Coal Company, Leven, Fife; Garnkirk Fire-Clay Company; Lanemark Coal Company, New Cumnock; D. Bruce Peebles and Co., Edinburgh; Monkland Iron and Steel Company; John M'Donald, Kirkwood Colliery, Glasgow; La Cour and Watson, Leith; James Darling, Blackhall Colliery Works; James Miller, Son, and Co., Glasgow; Andrew and James Stewart, Clyde Tube-Works, Glasgow; Alexander Thornton, Glasgow; Thomas Edington and Son, Glasgow; Hanna, Donald, and Wilson, Paisley; Darling and Co., Cleugh Colliery; Fullerton, Son, and Co., Edinburgh; Alder and Mackay, Edinburgh; Gray and Paul, Wilsontown; Cowdenbeath Coal Company; D. Y. Stewart and Co., Glasgow; Lesmahagow and Longlee Coal Company; Dunn Brothers, Glasgow; Capeldrae and Lochore Coal Company; Henry Caddell and Co., Grange; Young and Co., Glasgow; Wemyss Colliery; David Grant and Co., Edinburgh; Austine and Co., Glasgow; Hamilton, M'Cullock, and Co., Glasgow; R. C. Smith, Leith Walk, Edinburgh; R. and J. Gray, Porthead Colliery; Geo. Glover and Co., Glasgow; Galbraith, Reid, and Co., Glasgow; D. C. Mudie, Panmuir Foundry, Edinburgh; Armstrong and Hogg, Edinburgh; R. Maclaren and Co., Eglinton Foundry, Glasgow; Mr. D. M. Nelson, 135, Buchanan Street, Glasgow; Messrs. Hurl, Young, and Co., Glasgow; Mr. Alex. Thomson, Queen's Terrace, Glasgow.

an out-of-the-way term, and one which might almost be assumed to involve a good deal of strictly scientific knowledge and a good deal of prior information on the subject. But I will endeavour, with certain experimental illustrations, and by ridding my remarks of scientific language as much as possible, to make the subject not only interesting, but I hope also instructive to every one present.

Now, in the first place, we will direct our attention especially to those relations between one gas and another which are concerned with the weights of the gases; then, after that, of the solution of the gases in certain materials; after that, to what is sometimes looked upon as a very abstruse subject, the diffusion of gases, and also to another department—viz., the dialysis of gases. I hope all these are terms which will become familiar to you as I proceed.

The very nature of coal gas demands that we should consider the gases pretty much as a large class of bodies—because coal gas is not a single gas. It consists of a great many gaseous bodies—a kind of mechanical mixture of gases, similar to that obtained in solids where particles of coal and sand and other materials are all rubbed up together. In fact when you come to consider the chemistry of coal gas, you will find that even taking the shortest account of it, you have a large number of gaseous bodies present. Those are given on the table I have here:—

Coal.—Destructive Distillation—Gaseous Products after Separation of the Aqueous Fluid and Tar.

Hydrogen	H
Light carburetted hydrogen	CH_4
Heavy " "	CH_2
Volatile hydrocarbon	C_3H_6
Benzol	C_6H_6
Carbonic oxide	CO
Cyanogen	CN
Hydrosulphuric acid	H_2S
Ammonia	NH_3
Carbonic acid	CO_2
Sulphurous acid	SO_2
Bisulphide of Carbon	CS_2
Nitrogen	N

Some of these constituents are extremely useful for giving us light, others are not of so much value for that purpose, whilst some are prejudical to the illuminating power of the gas. And we must remember that this list does not take into consideration a whole series of substances which can be condensed from the crude gas, and which we call condensible products. These are given in the following table:—

Coal.—Destructive Distillation—Condensible Products.

Aqueous vapour, water holding in solution	Ammonic carbonate.	
	" sulphate.	
	" sulphide.	
	" chloride.	
	" ferrocyanide.	
	Oily Vapours.	
Liquid	Bensol	C_6H_6
	Toluol	C_7H_8
	Cumol	C_9H_{12}
		Naphtha.
Liquid	Anilin	C_6H_7N
	Picolin	C_6H_7N
	Leucolin	C_9H_8N
	Phenyl	C_6H_6O
Solid	Naphthalin	$C_{10}H_8$
	Paranaphthalin	$C_{11}H_{10}$
	Pyren	$C_{15}H_{10}$
	Chrysen	$C_{21}H_{14}$
		Heavy oil of tar.

But taking coal gas, as we obtain it, at an ordinary gas-jet, we have, not a single thing, but a mixture of a great many gases, all possessing chemical properties more or less distinct from each other, and having different weights, or, as we call them, specific gravities.

Now I have a table here which gives the names of some of the principal gases and vapours which are known to us in chemistry, and which also states their respective weights or densities;—

Gases and Vapours.—Specific Gravity or Density.
Air = 1·000.

Hydrogen	0·0692
Marsh gas	0·559
Ammonia	0·590
Steam	0·6235
Carbonic oxide	0·967
Nitrogen	0·971
Olefiant gas	0·978
Nitric oxide	1·039
Oxygen	1·1056
Trihydric phosphide	1·185
Dihydric sulphide (hydrosulphuric acid)	1·191
Hydric chloride	1·247
Nitrous oxide	1·527
Carbonic anhydride (carbonic acid)	1·529
Sulphur	2·230
Sulphurous anhydride (sulphurous acid)	2·247
Chlorine	2·470
Phosphorus	4·420
Bromine	5·540
Mercury vapour	6·976
Iodine "	8·716
Arsenic "	10·600

We generally have a notion that gases are all extremely light, and that they pretty much resemble each other in their general appearance. Take such a one as I have here in this jar. It appears, no doubt, to you as though the jar was wholly filled with air; but I may tell you that it is so different from air that it is 14½ times lighter than air, so that if I could get this jar filled with air and the contents weighed 14½ grains, and we then filled it with hydrogen, the gaseous contents would only weigh one grain.

Here is another gas, carbonic acid, which I have prepared from marble by adding to it some hydric chloride acid. This gas is quite similar in appearance to the hydrogen which we had in the other jar, and yet it is 22 times heavier. In fact, the gas which we have in the first jar, and which is the gas that stands first on the table of gases and vapours—hydrogen—is a gas which must be retained in a vessel closely covered up; and if we take this jar from the tray in which it stands, and hold it up a moment with the closed end of the jar uppermost, so that the gas cannot escape at the top, notwithstanding the mouth of the jar being open, the gas remains in the vessel on account of its great lightness. If this were a balloon, it would buoy it up. That the gas still remains in the jar you will see when I apply a light to the lower part. It burns with a sudden flame.

Then again, if I take another jar of the same gas, and instead of opening the vessel with its mouth downwards I open it with its mouth upwards, you will find that the gas begins to rise and to escape into the air. If I now take a taper, and introduce it into the vessel, you see I have to go down and down searching for the gas, and put the taper to the bottom of the jar without obtaining a rush of flame—in fact, the gas has practically escaped from the jar into the air.

But there are other ways of showing somewhat the same thing. I take another vessel containing hydrogen, which, as we saw, is so light that it keeps in the upper part of the vessel, and I take this glass pail, which at present contains nothing that will take fire—in fact, has simply air in it—and pass it up into this vessel containing the gas. I take it away and find that the comparatively heavy air that was in the glass pail has fallen out of it, and the light hydrogen, which was in the larger jar, has risen into the pail and taken the place of the air. We can now fire the contents of the small glass pail. We can take the little pail once again and put it up into the larger jar, and time after time we get a combustible and explosive mixture, which fires at the approach of a light. This shows without doubt the extreme lightness of this particular gas called hydrogen.

But then, again, we have another illustration of it in this small balloon, which is filled with hydrogen. The escape of the balloon into the air, when we release our hold of it, shows how much lighter hydrogen is than atmospheric air.

Yet another way of noticing the same thing. We can show the lightness of this gas by actually weighing it against ordinary air. I take here a portion of the hydrogen gas and put it into a small bell jar which we suspend beneath this beam, and when the gas is allowed to rise up into the bell jar the end of the beam rises, showing that the bell jar when filled with hydrogen is not so heavy as when filled with ordinary air. But a better way of noticing the lightness of this gas is to compare its density with that of a heavier gas.

For instance, I take the gas which has been prepared from marble and carry it to this part of the table, where I shall endeavour to find out whether it has any property which will show itself. This gas, instead of possessing a lighting power, has the power of extinguishing light, which can be observed by simply placing a lighted candle in the jar, when it is immediately extinguished. But another property of this carbonic acid gas is its great density. If we take this vessel, which is filled with the gas, and pour the contents over this lighted candle, it at once extinguishes the flame. We will now place a lighted candle in this other glass vessel which contains ordinary air, and proceed to pour in some of our heavy gas. What is the effect? You see the gas falls down and the candle is extinguished.

This is one of the gases which, compared with air—ordinary atmospheric air—we call a heavy gas, and we can show its heaviness in various other ways. One method is to try and pass it into this glass vessel suspended to the beam of the balance, and as we pour it in the particles of the heavy carbonic acid gas fall down, and the vessel with its contents then become heavier than when air was alone present, so that the balance-beam is depressed at that side.

One very striking way of noticing the weight of a gas may be observed in this manner. We have here a gas—chlorine—which is a good deal heavier than the heavier of the two gases I last worked with. Carbonic acid is 22 times heavier than hydrogen—chlorine is about 36 times heavier. I shall endeavour to show its weight by putting some starch into this vessel and afterwards adding iodide of potassium and mixing the whole contents of the vessel together. Now I take another vessel which contains chlorine; I open the bottle, hold the mouth downwards, and allow the contents to come in contact with the surface of the liquid. The gas immediately occupies the upper part of the vessel, and by agitating it a little you see this heavy gas has passed through the liquid and effected the chemical change which you notice in the darkening of the whole contents, owing to the formation of the deep blue coloured mixture.

So much for the question of the mere weight of gases, or, as we call it, their specific gravity or density. In fact, gases differ from each other in density far more than liquids or solids do from each other.

Another property in which gases differ from each other materially is in respect of their solubility. We have an illustration in the following table of the amount of solubility of various gases in water:—

Solubility of Gases in One Hundred Parts Water by Volume.

Hydric chloride	50,000
Ammonia	48,000
Sulphurous anhydride	5,000
Cyanogen	400
Dihydric sulphide	300
Chlorine	200
Nitrous oxide	130
Carbonic anhydride	100
Heavy carburetted hydrogen	8
Carbonic oxide	6·6
Nitric oxide	5
Oxygen	4·6
Nitrogen	2·5
Hydrogen	1·5
Light carburetted hydrogen	trace.

One of these you see is oxygen, so important for respiration. This gas is soluble to the extent of only 4·6 in 100 parts of water, but in the upper part of the table we have a gas—hydric chloride—which is soluble to the extent of 50,000 in 100 parts of water, and next to that ammonia, which is soluble to the extent of 48,000. That these gases have a solubility in water is evident in various ways.

I have here a vessel into which I can put a certain portion of water, so that

we may observe its power of dissolving gases. A flask is attached thereto, in which I place liquid ammonia, and we shall drive off the vapour of the ammonia by means of heat. The gaseous ammonia will pass along the tubes and ascend to the upper part of the large globe, and we shall now have this glass vessel filled with the ammonia vapour. The result will be that we shall afterwards be able to show the solubility of the ammonia gas in water. I shall do so by first introducing a portion of water into the globe, and then tilting the vessel into an upright position. We afterwards lower the neck into a large basin of water, and the result is that there is a great absorption of the gas owing to the solution of the ammonia in the water.

Gases have very often a chemical relation to each other. Here we have in this vessel two gases which have a special property of entering into a state of chemical union with each other. I have here a clear, transparent gas—nitric oxide—which has no particular colour. It contains the same elements or ingredients as are present in ordinary air, but the substances are there in a particular state of chemical combination. Now, if we open this, and surround it with a bell jar containing ordinary air, you will find we have at once developed a considerable quantity of this ruddy-coloured gas—hyponitric acid. In fact, we are working with two gases which have an important chemical action upon each other, and whenever they mingle chemical affinity comes into play, and we have the production of this very deep red-coloured compound.

Let us now endeavour to show you two other gases, or vapours, which to some extent may be regarded as having a chemical power of influencing each other. I have here a gas—nitric oxide—the same which formed the red colour you saw a moment ago, and I put into it a portion of bisulphide of carbon, and diffuse that throughout the vessel. You will find that it gives us a mixture of vapours which apparently have no great chemical action upon each other so long as they are unaided by heat. But if I bring into contact with this mixture a flame, you will find that a very rapid chemical action takes place. There will be no explosion, but a rapid burst of flame, showing the chemical energy which lies dormant in the mixture, until the application of heat, when we obtain a sudden flash of light.

We have pretty much the same thing even in regard to coal gas, with which many of you have to work so much. We have here certain vessels filled with coal gas. You will find that their contents present a perfectly colourless appearance, and that the gas itself has no power of combining with the air, and entering into union with the gases in it until you bring a light in contact with them. I need not tell you that if you turn on a gas-jet the gas will escape without any luminous appearance; but when a light comes in contact with the gas in the air, a chemical union takes place between the constituents of the gas and the air. It does not matter very much whether you place the gas in the air, or whether you attempt to place the air in the gas. Two things are required to produce this chemical union so as to form the luminous appearance, the one is the gas and the other the air.

The atmosphere contains a mixture of different gases.

Constituents of the Atmosphere.

Oxygen in 100 parts by volume	20·61	100·00
Nitrogen	77·95	
Carbonic acid	0·04	
Water vapour	1·4	
Ozone		Traces.
Nitric acid		
Ammonia		
Carburetted hydrogen		
Hydrosulphuric acid		Traces in towns.
Sulphurous acid		

Take, as an illustration, one of these vessels filled with ordinary coal gas, and just arrange that a jet of very pure air be brought into contact with it—in fact that you have the presence of that substance in the air called oxygen. We shall take this jet of gas, and so arrange matters that we have our gas, which is in this vessel, set fire to in the first instance; then we shall turn on a jet of oxygen, taking care that the gas is reduced in quantity, and introducing the jet of oxygen into the jar of coal gas, the oxygen lights up and burns vividly in the atmosphere of coal gas.

But there is another way in which this same point may be observed a little

better. If we take a large bell jar which contains a considerable quantity of coal gas, and just arrange that we have a small jet of oxygen passing into it, you will find that the jet of oxygen burns brilliantly in the coal gas. So that in this mode of burning of coal gas we have a very interesting point revealed to us—viz., that the air has to do with the combustion just as much as the coal gas has, and if you choose to burn ordinary air in coal gas you will get as good a luminous appearance as if you burnt coal gas in ordinary air.

The next point to which I wish to allude is in regard to what we call the diffusion of gases; *i.e.*, the power which gases have to mingle throughout each other—a power which they have quite contrary to what we notice with liquids. All gases, whatever be their respective weights, tend to diffuse rapidly throughout each other; but liquids do not necessarily do so. I take this vessel and put into it a certain portion of mercury. Upon this I put afterwards some coloured water, which you observe remains floating on the top. Above these we put a portion of ordinary oil, and that you see floats on the surface of the water. We, therefore, here get three distinct layers of liquids—liquids which have no ready chemical affinity for each other, but which simply assort themselves according to their weights. They remain in the order in which they were poured into the vessel—viz., the mercury, the water, and the oil. You might agitate them as much as you choose, but whenever they settle again, the order from the bottom would still be mercury, water, and oil.

Now that is what we notice with respect to liquids when they have no chemical action upon, and no solutive power towards each other. It is true that certain liquids have the power to mingle together. You have the familiar instance of alcohol and water—which we in the North are supposed to know so much more about than our southern brethren. If you take this alcohol and pour in a certain portion of water, the two at once thoroughly mingle with each other. You do not find either the one or the other floating on the surface. You might have expected that the alcohol, from being lighter, would float on the surface, and that the water, from its greater density, would sink beneath—as they certainly would do if these liquids had not a solutive power with each other.

But when we come to gases—no matter what the respective weights of those gases are—you find that they have a power of rising up and becoming uniformly diffused through each other. And curiously enough they do so at certain rates which can be determined.

I have here a table of the

Diffusion of Gases.

	Specific Gravity.	Velocity of Diffusion.
Hydrogen	0·069	3·83
Marsh gas	0·559	1·344
Steam	0·623	—
Carbonic oxide	0·967	1·0149
Nitrogen	0·970	1·0143
Olefiant gas	0·978	1·0191
Air	1·000	1·000
Nitric oxide	1·039	—
Oxygen	1·1056	0·9487
Dihydric sulphide	1·191	0·95
Nitrous oxide	1·527	0·82
Carbonic anhydride	1·529	0·812
Sulphurous „	2·247	0·68

This table gives the specific gravity of the gases named and the velocity of their diffusion. And here, curiously enough, we find that the lightest gases diffuse with the greatest rapidity.

Take, for example, the light substance hydrogen, which, taking ordinary air as the standard, does not weigh the fourteenth part of ordinary air, and you will find that it has the greatest power of diffusion of every other gas. In fact, if I arrange an apparatus where we can take our extremely heavy carbonic acid—that gas which fell down through the air so readily when we turned the vessel round which contained it—and put it down in this globe, and then arrange to slip in this tube above it, and afterwards put over it a globe containing that lightest of all gases—viz., hydrogen—you will find that the arrangement of having the heavy gas below and the light gas above is

only one which remains for a short time; and if by-and-by you proceed to estimate the exact composition of the gas in the upper part of this vessel, you will find that instead of it containing simply the lighter hydrogen, it will contain a certain proportion of the heavy gas, carbonic acid. No sooner are the two vessels brought together than the light gas begins to fall down through this tube, so that ultimately you will find it in the lower vessel; while a portion of the heavier gas you will find rising up, and occupying the upper part of the apparatus.

The rate at which gases diffuse is this—the lightest gases diffuse the quickest, but they do not diffuse exactly according to their lightness. Hydrogen is 14½ times lighter than air. It is 22 times lighter than the carbonic acid gas; but the rate of diffusion is not in the proportion of 22 to 1, but in the proportion of 5·5 to 1; that is inversely as the square root of the densities, which simply means that, instead of being at the rate of 22 to 1, it is at the rate of 5½ to 1.

Now this is a very important point, though it is one which is a little difficult to see at first. It is owing to this diffusion of gases that we have a thorough mingling of all the air in our rooms, and a thorough mixture of all the air outside of our rooms in our cities, and likewise in the different countries on the surface of the globe. Because, however we may have different mixtures of gases in ordinary air, and gases of different densities, as we have in the composition of the atmosphere, they all tend to diffuse and mingle throughout each other, according to this doctrine of the diffusion of gases.

Some liquids and certain substances in solution have a power of diffusing through each other. If a small vial be taken and filled with a solution of chloride of sodium (common salt), and carefully introduced into a jar containing water, the common salt will gradually rise out of the vial and diffuse itself throughout the bulk of liquid contained in the outer jar. If sugar or sulphate of magnesia be placed in the vial, the diffusion of these into the outer water will also take place, but not so rapidly; and if albumen (white of egg) or caramel (burned sugar) be inserted in the vial, the diffusion of those substances will take place very slowly. The following table gives the relative rates of diffusion of some liquids:—

Diffusion of Liquids.—Approximate Times.

Hydrochloric acid	1·00
Chloride of sodium	2·33
Sugar	7·00
Sulphate of magnesia	7·00
Albumen	49·00
Caramel	98·00

This experiment may be conducted in another way by placing the substances to be diffused in the lower part of a tall jar, and having water above. As the substance rises up and diffuses itself through the upper liquid, the rate of diffusion is observed. The following table gives the results of observations made on this point:—

Tar Diffusion.—Ten per Cent. Solutions for Fourteen Days.

No. of Stratum	Chloride of Sodium.	Sugar.	Gum.	Albumen.
1	0·104	0·005	0·003	—
2	0·129	0·008	0·003	—
3	0·162	0·012	0·003	—
4	0·198	0·016	0·004	—
5	0·267	0·030	0·003	—
6	0·340	0·059	0 004	—
7	0·429	0·102	0·006	—
8	0·535	0·180	0·031	0·010
9	0·654	0·305	0·097	0·015
10	0·766	0·495	0·215	0·047
11	0·881	0·740	0·407	0·113
12	0·991	1·075	0·734	0·343
13	1·090	1·435	1·157	0·855
14	1·187	1·758	1·731	1·892
15 & 16	2·266	3·783	5·601	6·725
	9·999	10·003	9·999	10·000

It will be observed that the chloride of sodium rises quickest in the jar, whilst the albumen lags behind and diffuses slowly, in fact does not reach one-half the height of the water in the jar during the time required for the chloride of sodium to reach the top layer.

We have also the transpiration of gases, which means the passage of gases through extremely minute tubes. If I take a piece of glass tube and heat it and draw it out like this piece of rubber tube, it still remains a tube, and if we attempt to pass gas through it we carry out what is called the transpiration of gas. I have here a table which shows the

Transpiration of Gases.

	Time, Equal Vol.		Relative Velocity.
Oxygen	1·0000	..	1·000
Air	0·9030	..	1·107
Nitrogen	0·8768	..	1·141
Nitric oxide	0·8764	..	1·141
Carbonic oxide	0·8737	..	1·144
Nitrous oxide	0·7493	..	1·334
Hydric chloride	0·7363	..	1·361
Carbonic anhydride	0·7300	..	1·369
Chlorine	0·6664	..	1·500
Sulphurous anhydride	0·6500	..	1·538
Dihydric sulphide	0·6190	..	1·614
Marsh gas	0·5510	..	1·815
Ammonia	0·5115	..	1·935
Cyanogen	0·5060	..	1·976
Olefiant gas	0·5051	..	1·980
Hydrogen	0·4370	..	2·288

You see by this table that oxygen is the slowest in regard to time, and that air comes next afterwards. All these gases differing in properties—light and heavy gases—have certain rates at which they do pass through these tubes; but, curiously enough, we have not yet determined any law which regulates the rate of transpiration. We do not find that the heavier gases pass quicker than the light gases, or the light ones quicker than those which are heavy, so at present there is no law by which we can determine the rate of transpiration as is the case with the diffusion of gases.

There is one other important point in connexion with gases, and that is with regard to the passage of one to the other by means of a diaphragm. This subject was worked out very fully by the late Professor Graham, the Master of the Mint, one of those bright stars that our southern brethren sometimes take away from our northern regions. To him we are indebted for nearly all we know as to how gases do pass through and mingle with each other. Well, he studied the subject in connexion with both liquids and the gases, and probably the best way of seeing how far or how important are the discoveries with regard to the gases would be first to explain the question as to the liquids. And it may be shown in this way. We take a diaphragm such as this piece of parchment paper. All you require to do in order to make the parchment paper is to act upon it with a certain mixture; and we find the best mixture for the purpose is oil of vitriol and water. I put a mixture of oil of vitriol and water into a vessel and draw a piece of paper through it. But then we must have another vessel containing a solution for the purpose of neutralizing the acid which has come from the first one. This is a solution of ammonia and water. Now, I take a piece of ordinary blotting paper—a paper which you know has no great strength of itself, and which if passed, as I now pass it, simply through water, comes out in such a condition that you can tear it readily to pieces, for there is no cohesive strength in it whatever. But let me take a sheet of the same paper and pass it through the oil of vitriol and water; then transfer it to the second vessel containing the ammonia and water, so as to neutralize a portion of the acid left in it, and subsequently wash it thoroughly. We now take it out, and I have a paper which is like a piece of leather—it is so tough that you try in vain to tear it to pieces. This paper forms about the best material for carrying on our experiments in the dialysis of liquids. But there is one point in reference to the preparation of the paper which I may mention, and that is

that in the first vessel you must have exactly two parts of vitriol and one of water. If you have it stronger it will not do, and anything weaker will not do. If, for instance, I take another piece of the same paper, and treat it with a less strong solution of the vitriol, you will see that in drawing it through the paper hardly keeps itself together, but breaks up into shreds. This shows how extremely nice we must be in having the exact proportions—two parts of vitriol and one of water—to enable us to prepare this paper.

Now, I take a piece of this paper so prepared, and soak it in a vessel containing water, and stretch it across a frame made of a piece of ordinary gutta percha with a ring around it, in this way, and I very quickly form a kind of sieve. I take this sieve and put it in an outer vessel in which we can float it. You will find that if I put into this sieve certain substances, some of them will pass readily through and others will not.

I take as an illustration a portion of ordinary minced meat, to show one important application of it. I add to that a small portion of arsenic and mix them together, forming a compound of animal matter and the arsenic, and I throw the whole of this upon the diaphragm. Let there be between the outer and the inner liquid this piece of parchment paper, and you will find that the elements of the meat hardly go through at all, but the arsenic begins at once to pass through into the outer liquid, so that by-and-by you will find a certain proportion of it there.

Now, a law has been deduced as to the manner in which liquids and solids can pass through this diaphragm, and it has been found that those which are crystalline pass through very quickly—such as sugar, Epsom salts, &c. Other bodies, or, as we call them, albuminous matters, such as white of egg, pass through very slowly indeed.

Dialysis.—Relative Diffusate—Two per Cent. Solutions.

24 Hours at 12° C.

Sodic chloride	1·000
Picric acid	1·020
Ammonia	0·847
Thein	0·703
Salicin	0·503
Cane sugar	0·472
Amygdalin	0·311
Extract of quercitron	0·184
„ logwood	0·168
Catechu	0·159
Extract of cochineal	0·051
Gallo-tannic acid	0·030
Extract of litmus	0·019
Caramel	0·005

In this way, therefore, we find that liquids or solutions of substances have the power to pass through the diaphragm or of being subjected to the process of dialysis, the crystalline passing much more quickly than the albuminous.

Well, working out the subject in connexion with gases, it was found that using very thin pieces of india-rubber or caoutchouc, and stretching these across vessels or tubes, we can pass gases through them, and that some gases have the power to pass through quickly in one case and slowly in another; in fact, that certain gases pass through with great rapidity and that others are kept back. The rate of the diffusion of gases through an india-rubber diaphragm or septum is given in this table :—

Dialysis of Gases.

Septum of India-rubber.

	Time, Equal Vol.	Relative Velocity.
Nitrogen	13·585	1·00
Marsh gas	6·326	2·15
Oxygen	5·316	2·55
Hydrogen	2·470	5·50
Carbonic anhydride	1·000	13·58

Now, one of the results of this dialysis of gases may be of the greatest importance with regard to the composition of our own atmosphere. You find that in 100 parts by volume of atmospheric air there are nearly 21 parts of oxygen and 79 of nitrogen. These are the proportions most conducive to health, and which are present in all free air. But if you attempt to pass this air through a diaphragm, you will find that the oxygen will pass at the rate of 2½ times, while the nitrogen will pass only to the extent of 1. And this leads to the consideration of the question of the filtration of our air. We can actually increase the quantity of the oxygen, which is the invigorating substance, by transmitting the air through this septum of india-rubber. How largely this may be done is shown in the following table:—

Atmospheric Air.

A	Oxygen .	$21 \times 2{\cdot}55 =$	$53{\cdot}55$ or $40{\cdot}4$	per cent.
	Nitrogen .	$79 \times 1{\cdot}00 =$	$79{\cdot}00$ „ $59{\cdot}6$	„
B	Oxygen .	$40 \times 2{\cdot}55 =$	$102{\cdot}00$ „ $61{\cdot}72$	„
	Nitrogen .	$60 \times 1{\cdot}00 =$	$60{\cdot}00$ „ $38{\cdot}28$	„

These figures show (A) that if ordinary atmospheric air be transmitted through the rubber septum, the per centage of oxygen is increased to 40·4, and (B) if this oxygenized air be again transmitted through a layer of rubber, the per centage of oxygen will be still further increased to 61·72 per cent.

The dialysis of gas, therefore, is of very great moment in respect of the separation of one gas from another, and may come to be of great value with respect to increasing in the atmospheres of our rooms a larger proportion of oxygen, because if the windows of our rooms had their frames fitted with a septum of india-rubber the proportion of oxygen might be increased greatly above the proportion which we find as the normal quantity in the open atmosphere.

One other point before I have done. Certain gases have the power of being absorbed by metals, and transmitted to a very large extent indeed. The metals which have the power of absorbing and transmitting gases are principally the metal platinum, and another metal called palladium. When ignited the platinum transmits hydrogen with great rapidity, whilst it is practically closed to marsh gas. The relative rates of diffusion are as follows:—

Septum of Platinum.

Hydrogen	100·0
Marsh gas, &c.	0·01

Platinum has long been known to have this curious property of compelling a union of gases. If you take even our ordinary coal gas, and allow that coal gas to impinge upon a piece of platinum, you will find that you can readily support the platinum at a red heat. I take as an illustration a quantity of gas which we can burn from this jet; it is rather a large jet, and we can consume a very considerable quantity of gas. We extinguish the gas, and having got a small piece of platinum—which has the power to absorb gas—we shall have an illustration of the manner in which it is done by the way in which it tends to keep up the combustion after it has left this source of heat. You here notice how in a mysterious way the platinum keeps glowing in the upper part, and will continue to glow while the mingled gas and air surround it.

The mysterious way in which this piece of platinum keeps at the high temperature is due to this—that it has the power of condensing within its pores a certain portion of the gases, and compelling their chemical union very quickly within those pores, and this chemical combination leads to the development of the heat which keeps the platinum at a high temperature.

Another way to observe the same phenomenon in a more striking manner is to work with ammonia and oxygen. I take here some of the liquor ammonia, and will place it in this flask. The vapour diffuses itself throughout the upper part of the vessel. Then I take a piece of platinum and heat it first in the gas. You see it glows as long as the flame is connected with it. And now I put it into the vessel containing the vapour of ammonia, and it still continues to glow in this vessel, so that you see it is absorbing a certain amount of gas, and still proceeding to cause a certain combustion of the constituents. I am now going to throw in a little oxygen, which will increase the energy

of the action, so that the platinum, which has been at a red heat, will rise to a white heat, and there will be a much more rapid combustion of the constituents in our vessel, and explosion after explosion of the mixed vapours will take place. These combustions and explosions are due to the particular power which the platinum has of absorbing certain gases, and causing a chemical union within its very pores.

One of the substances I referred to—palladium—absorbs 600 or 700 times its own volume of oxygen; in fact, it combines with it so thoroughly that the alloy may be stamped out into medals, and still retain that large volume of gas in it.

The absorption of gases by charcoal has been long known, and the results of many observations are given in the following tables:—

Absorption of Gases by One Part of Charcoal by Volume.

Ammonia	90·0
Hydric chloride	85·0
Sulphurous anhydride	65·0
Dihydric sulphide	55·0
Nitrous oxide	40·0
Carbonic anhydride	35·0
Heavy carburetted hydrogen	35·0
Carbonic oxide	9·4
Oxygen	9·2
Nitrogen	7·2
Light carburetted hydrogen	5·0
Hydrogen	1·7

Absorption of Gases.—Relative Values of Wood, Peat, and Animal Charcoal.

Charcoal.	Ammonia.	Hydric Chloride.	Dihydric Sulphide.	Carbonic Anhydride.	Oxygen.	Sulphurous Anhydride.
Wood	98·5	45·0	30·0	14·0	8·0	32·5
Peat	96·0	60·0	28·5	10·0	6·0	27·5
Animal	43·5	—	9·0	5·0	5·0	17·5

One part of charcoal, therefore, absorbs fully 90 times its own volume of ammonia vapour.

I have endeavoured to-night shortly to refer to some of those peculiar physico-chemical properties of gases which may not come every day within the cognizance of all of us. These properties of diffusion and dialysis, both with respect to gases and liquids, are undoubtedly of the greatest importance, though we cannot as yet, in many ways state what their full utility is. In the living system all these processes must perform most important functions in regard to the composition of the air of our rooms, and the absorption of liquids and solutions, as well as the interchange of gases. It is probable that even in the manufacture of coal gas some of those peculiar properties may have a technical bearing.

The practical utility of many of my observations may not be observed at once, and may be still hard to seek. But the history of all inventions shows that little by little is the structure of discovery reared, and that scientific facts and observations often lie dormant for years, even for generations; then some happy thought links them together, or some happy discovery reveals the missing link, and the world is enriched by the development of some great branch of industry conducing to the welfare of mankind. But independently of the utilitarian aspect of the question, we ought to endeavour to learn truth—to know truth. To do so, man becomes elevated from a mere labour-machine to be an intelligent son of toil, and a more faithful servant of the trust reposed n him by his Maker, the Creator of all.

On the motion of the PRESIDENT, a cordial vote of thanks was passed to Dr. Macadam for his able and interesting lecture.

At the conclusion of the lecture, the audience returned to the museum, and resumed their promenade through the various galleries, inspecting the objects of interest, and partaking of the refreshments so bountifully provided for them by their entertainers, every one expressing their warmest appreciation of the very excellent arrangements made for their enjoyment.

WEDNESDAY, JUNE 11.

The PRESIDENT took the chair at eleven o'clock this morning, and the reading of papers was resumed.

Mr. T. H. METHVEN (Bury St. Edmund's) read the following paper on

COALS WASTED IN GAS-WORKS.

With coals at 21s. instead of 6s. free on board in the Tyne, it becomes every one concerned in the manufacture or consumption of gas to give the coal question his careful consideration.

In a paper recently read by Sir William Armstrong, he stated that he considered the high price of coals was chiefly caused by a slight excess of demand above the supply, and that as there was no hope of an increased output, the only possibility of lower prices was in a diminished demand. He gave the result of his own action in the matter, which was caused by the high price of coals and the above views. Instead of continuing the use of several engines and boilers of ordinary construction, he erected a Corliss engine and improved boiler, and reduced the consumption of coals from 50 tons to 24 tons per week.

It is just possible the justly eminent man would have cared nothing for the Corliss engine, which has been manufactured for years, and may be seen in use on the opposite side of the Forth at Kirkcaldy, had coals continued at the old prices.

As manufacturers are compelled to economize fuel, surely in gas-works, in which coal is so important an item, the utmost economy should be used. I therefore, through this association, would direct the attention of gas directors in towns of 6000 inhabitants and under to the subject. To them it is an important one. In many cases, unless they do so, there will be no dividend, in others a reduction, or rather the prevention of an additional charge of 1s. or 1s. 6d. to the consumers may be effected. In such towns, with coals at 15s. per ton, and gas at 5s. 6d. per 1000 feet, there was no difficulty in paying the usual dividend of 5 or 6 per cent. The management of such gas-works is usually in the hands of directors who attend to the receipts and payments of a secretary, who is often a rate collector, banker's clerk, or small tradesman, who makes out and collects the accounts, and of a working manager who keeps up the supply of gas and attends to consumers complaints.

By this system you have a subdivision of labour and also of responsibility. There is certainly a head.—The directors, who know nothing of the practical part of gas-making, whilst the only man who knows, or is likely to know anything of the matter, has no power or responsibility, except to keep the gas-holder always afloat. Usually no one connected with the undertaking has any thorough knowledge of the subject, nor understands the proper system of management necessary in larger works, and not less so in small ones. No one is responsible for, or perhaps knows of, the waste. Need we, therefore, wonder that the amount of gas paid for that is obtained from every ton of coals carbonized is from 5000 to 6000 feet per ton?

In some well-conducted works of the size under consideration, the sales per ton of coals carbonized range from 7000 to 8000 feet, whilst in those of the metropolis they range from 8000 to 9000 feet. Certainly there is room for improvement upon the 5500 feet, which a considerable experience leads me to state as a fair average upon which we may calculate as usually obtained in the towns referred to. If I am correct, the following balance-sheet will be allowed for a town of 5000 inhabitants, taking the consumption at 800 feet per head and coals at former prices:—

Balance-Sheet No. 1.

Receipts.—4,020,000 feet of gas at 5s. 6d.				£1105	0	0
375 chaldrons of coke at 12s. per chaldron (18 bushels per ton)				222	0	0
7500 gallons of tar at £5				37	10	0
				£1364	10	0
Expenditure.—750 tons of coals at 15s., producing 5500 feet at consumer's meter .	£562	10	0			
Wages and salaries	260	0	0			
General expenses	220	0	0			
				1042	10	0
Balance profit				£322	0	0

This would allow of a dividend being paid at the rate of 6 per cent. on £5000, which will not be considered an unreasonable capital. I have been liberal in my allowance for coke sold. Seldom are 18 bushels per ton set aside for sale. It has been almost unsaleable on account of the large quantity in the market. Had only the proper quantity of coals been carbonised in the gas-works, a readier sale and higher price would have been obtained for it. Under proper management, you will readily allow

Balance-Sheet No. 2.

Receipts.—4,020,000 feet of gas, as before, at 5s. 6d. . . .				£1105	0	0
325 chaldrons of coke at 12s. per chaldron (20 bushels per ton)				195	0	0
5360 gallons of tar at £5				26	16	6
Ammoniacal liquor, same value as tar				26	16	6
				£1353	13	0
Payments.—535 tons of coals at 15s., required to produce the above gas at 7500 feet per ton at consumer's meter . . .	£402	0	0			
Wages and expenses, as before. . .	480	0	0			
				882	0	0
Balance profit				£471	13	0

This would allow of a dividend of 9¼ per cent., or, should the directors have an objection to take more than 6 per cent., they might reduce the cost of gas 10d. per 1000 feet.

The high price of coal has done away with all such balance-sheets as No. 2, so that now we can have, with the management as in No. 1 and the present price of coals,

Balance-Sheet No. 3.

Receipts.—4,020,000 feet of gas, as before, at 5s. 6d. . . .				£1105	0	0
375 chaldrons of coke at 24s. per chaldron (18 bushels per ton)				444	0	0
7500 gallons of tar at £5				37	10	0
				£1586	10	0
Payments.—750 tons of coals at 30s. per ton, producing 5500 feet at the consumer's meter	£1125	0	0			
Wages and salaries, as in No. 1. .	480	0	0			
10 per cent. increase	48	0	0			
				1653	0	0
Balance loss				66	10	0
An addition of 1s. 10d. per 1000 feet				367	10	0
Sufficient to pay 6 per cent. . .				301	0	0

With good management, as in No. 2, and with coals at 30s. per ton, we will have

Balance-Sheet No. 4.

Receipts.—4,020,000 feet of gas, as before, at 5s. 6d. . . .				£1105	0	0
325 chaldrons of coke at 24s. per chaldron (20 bushels per ton)				390	0	0
Tar and liquor, as in No. 2				53	13	0
				£1548	13	0
Payments.—536 tons of coal at 30s., producing 7500 feet per ton at consumer's meter	£804	0	0			
Wages, as before	480	0	0			
10 per cent. increase	48	0	0			
				1332	0	0
Balance profit				£216	13	0
An addition of 6d. per 1000 feet would leave enough for 6 per cent. dividend				100	10	0
				£317	3	0

In order to maintain a fair comparison, I have supposed the consumption of gas stationary; but if the district in which the works are situated is an increasing one, and could all the coal now wasted in balance-sheet No. 3 be made into gas and sold, the receipts would be increased £412 10s., and there would remain a net profit of £346, which would pay more than a dividend of 6 per cent.

In England and Wales there are about 350 towns with a population under 6000. These in the aggregate consume annually, on the basis of the moderate estimate on which my argument is founded, 144,000 tons. If only 5500 feet of gas instead of 7500 feet are sold, it follows that 44,000 tons of coals, worth (after deducting the products) £44,000, are wasted. This is equal to £125 per gas-work per annum—a sum in many cases exceeding the dividend paid. My estimate of the consumption of gas is only suitable for agricultural towns, which often use less than half of that used in manufacturing towns. The waste may therefore be nearer to 88,000 than 44,000 tons. Certainly this might be prevented. Should any one doubt my statements, let him analyze the next balance-sheet he may receive.

The cause of this waste is the want of skilful superintendence, for no director, however clear in his own profession or trade, can have the ability which is needed to produce gas at the lowest cost. It is only by years of patient attention that this can be obtained.

Now as to the causes of the mismanagement, these are as follows:—

1. Badly set and worked retorts.
2. Clay retorts, with insufficient attention.
3. The want of a station-meter, or neglect to use it.
4. Neglect to weigh or measure the coals.
5. The want of or neglect to use a governor.
6. Badly laid mains or service-pipes.
7. Unsuitable burners and arrangements for the public lamps.

If gas directors wish to be paid for 7500 feet per ton, they must attend to the whole of these matters, or obtain some one who can do so. If not, their gas-works must remain as badly managed as they now are, and they must go without a dividend if prevented by any local act from raising the price of gas. If, however, they are not hampered, and wish their usual dividend, unless they improve their management gas consumers will have to pay an extra 1s. per 1000 feet for their gas, to cover the waste, of which the majority of gas directors are quite ignorant, and which might with ease be prevented.

There was no discussion on this paper, but a vote of thanks was given to the writer.

Mr. F. W. Hartley (London) read the following paper on

COAL GAS AS A FUEL.

The employment of coal gas, and of other inflammable gases, in the place of solid fuel, has been advocated by inventors and others; but, as far as the author's knowledge extends, no attempt has been made heretofore to show, by reference to known facts, and by calculations based thereon, the relative commercial value of coal gas and of solid fuel for heating purposes, and it occurred to him that a short suggestive paper might lead to a discussion embracing practically valuable information. He has not attempted to treat the subject exhaustively, for to do this would necessitate a paper of much greater length than he could spare time to write, or the members would possibly care to listen to the reading of, but merely essayed to put forward certain salient facts and the conclusions in relation to them. Some of the facts and conclusions are antagonistic to the use of coal gas as a fuel; but although this is the case, and it may appear singular to argue against the use of coal gas before such an association as this, the author feels quite satisfied that it will be understood that his only motive is to establish a sound basis on which to erect the superstructure of application.

The object of the paper is, then, to show, in respect to certain applications, the relative value of coal and of coal gas as heat-developing agents; for coke need not be considered at all, inasmuch as experience shows that good coke

generally evolves on combustion as much heat for equal weight as the coal from which it is produced.

It is desirable first to deal with coal, and the value of coal for heating purposes is usually expressed by a statement of the number of pounds of water which 1 lb. of coal is capable of converting into steam from the boiling point, or of raising 1° Fahr. in temperature. The heating power of coals differs very widely, the evaporative power of those of Great Britain varying in practice from about 6 lbs. to as high as 10 lbs. water converted into steam from the boiling point, or from 5802 lbs. to 9670 lbs. water raised through 1° Fahr. There is, besides, a very wide difference between the theoretic value calculated from composition and the actually attainable heating value of coals, and this difference is shown very strikingly in the tables contained in the report published some years since of Sir H. De la Beche and Dr. Lyon Playfair. A few examples of this difference will suffice. The actual evaporative value of anthracite is shown to be 9·46 lbs. water boiled off, of Llangennech 8·46 lbs., and of Wallsend (Elgin) 8·46 lbs., of which the theoretic values are respectively 14·593 lbs., 14·26 lbs., and 13·422 lbs. Of course, in practical application, much depends on the form and construction of the boiler, its size, and the arrangement of the furnace and the flues. It is certain, however—and an investigation of recorded facts will prove this—that with a thoroughly good furnace coal the evaporative value does not rise higher than 9 lbs. water to the pound of coal, although it is perfectly true that with water tube boilers the evaporative power rises sometimes to 10 lbs., or even somewhat higher. If, then, the evaporative power of coal be taken at the usual average of 9 lbs., it will be high enough for the purpose of comparison. If 9 be multiplied by 967 (the number representing the latent heat of steam at 212° Fahr.), the product is 8703, which equals the number of pounds of water which 1 lb. of coal will raise through 1° of Fahrenheit's thermometer.

It is now needful to consider what has been the practical results with coal gas, and the best illustration which can be taken is the statement contained in the paper read by Mr. Goddard to this association in June, 1870. That gentleman brought under the notice of the meeting an admirably constructed boiler with a gas furnace, and stated that 27 gallons, or 270 lbs. of water were raised through 145° Fahr. by the combustion of 60 cubic feet of coal gas. This result is equal to raising 39,150 lbs. water through 1°, and shows that 13·2 cubic feet (nearly) of gas gave the same amount of heat as 1 lb. of coal. It is but fair to remark that this result shows also that the gas employed, which I assume to have been common coal gas, must have been of a tolerably high illuminating power. If, then, the gas be taken at 4s. per 1000 cubic feet and coals at 25s. per ton (a price quite low enough now for localities at a distance from the pits), then 4s. worth of gas would be required to produce the same amount of work as eleven pennyworth of coal nearly.

In some of the large water-works, and with engines worked on the expansive system, less than 3 lbs. of coal suffice per horse power per hour, and it is claimed for some engines of 50 to 100 horse power, that about 2 lbs. of coal, or less, suffice per horse power per hour; but in smaller stationary engines there can be no doubt that the consumption ranges from 7 lbs. to as high as 14 or 15 lbs. of coal per horse power per hour, and as gas is really available only for small engines, these weights must be taken as the basis for comparison.

Mr. Goddard stated that with the Jackson boiler 100 cubic feet of gas were required per horse power per hour; it thus follows that the cost per hour would be for gas 4·8d., as against 0·94d. for 7 lbs. of coal, or as against a fraction over 2d. for 15 lbs. of coal; so that in the face of these figures gas is manifestly a very expensive fuel, and it is quite evident that whenever engines are required for continuous work there can be no question as to which kind of fuel is to be preferred on economical grounds. Mr. Goddard was quite clear upon this point, for he spoke of Mr. Jackson's invention as useful when power is needed intermittently; but he said this in favour of the gas, "that a very small modicum of gas is required to maintain the pressure of the steam when the engine is at rest." A large allowance, therefore, must be made, in instituting a comparison of cost of fuel, when an engine has to be used intermittently, and it is quite possible that when the intervals of action are wide apart, and the duration of action short, that gas would be the most advantageous fuel for

engines not exceeding 2 or 3 horse power, the more especially as with gas there is no stoking and clinkering to be done, no wear and tear of furnace and fire-bars, and in fact so little attention needed that the engineman would be able to attend to a much greater extent to other work, thus reducing to a mere trifle the cost of attention to the engine. In respect to gas used explosively in the gas engine, it would seem, if published statements may be relied upon, to be more economical than when used to raise steam for an engine; this is quite reasonable, and therefore to be expected, the relative cost being 4·8d. per horse power per hour for steam raising, as against about 3d. when used explosively. All these facts and reasonings tend conclusively to prove that gas can never on the large scale compete with solid fuel, whether the application be for heating water, to supply steam to engines, to warm buildings, hot-houses, &c., &c., for even if coal gas were manufactured for the purpose, at one-third the price herein assumed, so large a margin would be left in favour of solid fuel as to put gas out of competition. Very similar relations hold in respect to the two kinds of fuel when used for cooking on the large scale, and when the viands are for the greater part boiled or steamed. A few pounds of coal will do a wonderful amount of work in a well-constructed kitchener. It is asserted very positively in respect to one celebrated kitchener or cooker which has come under the author's notice, with which most of the viands are steamed, that the expenditure of fuel in cooking dinners for 150 people is only 49 lbs. of coal. This quantity at 30s. per ton would cost very nearly 8d., while the same heat generated from the consumption of gas would cost, at 4s. per 1000 cubic feet, something like 3½ times the money. In this illustration, however, the solid fuel is used under the most favourable conditions—mainly to vaporize water into steam—and the whole operation is carried out in the most careful and systematic manner. The relations between gas and coal are very different where what may be called dry cooking—baking or roasting—is concerned. For this purpose, on a moderate scale, gas is by far the most advantageous, because it can be put into full operation the instant it is wanted, and its combustion stopped the instant that the necessity for its employment ceases. There are in addition certain other important advantages with gas, apart from mere cost, which it is not the purpose of this paper to treat of. One fact is brought out very strongly in the foregoing statement relative to the cooker—namely, the great amount of work to be done at little cost with steam. This fact is to a large extent lost sight of in the application of gas. It is thought, as a rule, sufficient to provide so many burners, and as many pots in which actually to boil the food in water. During this boiling a large proportion of the water is driven off as steam, and its heat wasted, the value of which must be at once apparent when it is remembered that one pound of water (27·28 cubic inches) evaporated becomes nearly 27 cubic feet of steam, and contains heat enough to raise 5½ lbs. of water from 32° to 212°.

Two important purposes for which gas can be used with economy are brazing and soldering. In relation to brazing, the author is, however, unable to furnish statistics; but as regards soldering, the solid fuel being charcoal at 2s. per sack, gas has been proved, from the author's own experience, to be from 20 to 30 per cent. cheaper.

The next comparison which might with advantage be instituted between gaseous and solid fuel is in respect to relative value for warming rooms, the solid fuel being burned in an open fireplace, and the gas in the best form of gas-stove. There are, however, two difficulties in the way—first, in ascertaining what is the average proportion of the heat power of the solid fuel which is really effective, and this must depend on the form of the grate and on the area of the chimney, which is generally much larger than is needful for the purposes of combustion. It has, however, been variously estimated that in an open fire only as much as from one-eighth to one-third of the heating power of the fuel is utilized, the rest escaping up the chimney.

The next difficulty is in relation to the stove in which the gas is to be burned. Gas-stoves are of all imaginable constructions, like gas-burners are, and certainly there seems fully as much scope for improvement in gas-stoves as there was for improvement in the Argand burner, when Mr. Sugg devoted himself to its study. There are the simple cylindric, double cylindric, cone and cylinder, multi-cylindric or tubular, and bee-hive stoves, of wrought iron, cast iron, or porcelain; some being ventilated, and serving only to warm by

radiation and by convection from the air coming into contact with the heated body of the stove, and others non-ventilated, which not only warm by radiation and convection, but also by the discharge of the hot gases of combustion into the apartments. The latter kind of stove, whatever be its merits in other respects, is most objectionable, and should, in the author's opinion, never be employed. It has been urged in their favour that there can be no more harm in burning gas in a stove than in a gas-burner. This argument is utterly illogical. In the one case gas is burned for the production of *light* and in the other for the production of *heat*. If, therefore, rooms in which gas is being burned for lighting become oppressive, the simple opening of a door or window for a minute or two serves to freshen the atmosphere, while the usefulness of the gas is still preserved. Not so in heating; in this case the admission of fresh air to a large extent nullifies the very object for which the gas is employed, and the room is cooled to an undue extent until again it becomes oppressive, and the same wasteful process has to be repeated.

It is not possible, however, to show, by calculation, any striking amount of deterioration in the atmosphere of a tolerably close room warmed by the combustion of a moderate quantity of gas, but sensations may be referred to. Now every one here must be sensible of the oppressiveness of close rooms when warmed by the combustion of gas in such stoves as have been just objected to. It is quite true that all close rooms warmed by the contact of the air with highly heated surfaces are apt to feel oppressive, from causes which are tolerably well known; but certainly it cannot be wise to add another evil, which is done when carbonic acid and sulphurous acid gas—it may be in small but nevertheless irritating quantities are delivered into the air from the burning fuel. Lately a very attractive form of stove has been brought out—namely, the "Reflector," or "Cheerful" stove, but the author believes that the most economic application, and certainly the most satisfactory to our predilections, is the heating up of solid material in an open grate, not, however, in an ordinary grate, as is the usual plan, but in one forming part of a cubical or cylindrical stove, the upper portion, and possibly other parts of such stove being multi-chambered, these being so divided that one set should serve to carry off the products of combustion, and the others for air to circulate through and be effectively warmed. In some such construction as this there would be the cheerfulness of an open fire, the maximum of heat would be utilized—the author believes as much as 8-10ths or 9-10ths of the whole heat generated—the products would be carried off, and with them sufficient of the air of the apartment to keep the atmosphere in a healthful condition. Of course the author is quite sensible of the difficulty of carrying out such a construction with very small gas-stoves, and also the many cases which arise in which stoves are wanted for use in rooms where anything more than what may be called general or accidental ventilation is not possible, owing to the profound indifference which builders manifest too frequently in respect to provisions for systematic ventilation. But to institute any comparison, data must be established, and, upon the grounds given, it will be assumed that 8-10ths of the heat of the gas may be utilized, and one-fourth of that from coal burned in a chimney grate. It has been shown that under a boiler 1 lb. of coal and 13·2 cubic feet of gas produce the same amount of heating effect. Under the conditions now assumed, 4 lbs. of coal and 16·5 cubic feet of gas would be equal in heating effect. Now these quantities cost—coals being 30s. per ton and gas 4s. per 1000 cubic feet—coal 0·6428d., and gas 0·7920d; showing the latter to be really advantageous when all things are taken into account, such as the absence of dust and dirt, the rapidity with which the fire can be made, and the equal rapidity with which the expenditure can be put an end to when heat is no longer wanted. True this conclusion is arrived at speculatively, but really it grows out of extended observation, although not supported by absolute and specific experiments.

The author intended, however, to enter into a series of experiments for the purposes of this paper, and also to collect information as to the economic value of gas for heating small hothouses, conservatories, artificial incubation, &c.; but, unfortunately for himself, or for his credit, pressure of business first, and next his own indifferent health during some time, led to delay, and finally he has been compelled, in fulfilment of his promise, to write this little paper under the pressure of a series of personal troubles of a very distressing kind,

which have at times so affected his nervous system as to render mental exercise impossible. He has, therefore, been obliged to produce such a paper as was possible to him under the circumstances, and most sincerely trusts that its deficiencies will be fully compensated for by facts brought out in the discussion.

The PRESIDENT said this was a subject which deeply affected gas companies, and it had been most ably brought before the association by the writer of the paper. Anything that would promote the consumption of gas during the hours of the day must be of the greatest consequence to their interests, and he hoped that much good would follow the discussion of the question.

Mr. SUGG (London) desired to offer a few remarks at the outset, and said that had he known the line which Mr. Hartley would have taken in his paper he should have been prepared with a few facts which, while perhaps disproving one part of his observations, would have supported the rest. With respect to the use of gas for heating of rooms by the boiling of water, there was one very important thing to be attended to, and that was to prevent the heat communicated to the boiler from escaping at the outside surface. This might be done by felting the boiler round, or enclosing it in a box and simply allowing the products of combustion to escape through a number of small holes in the box. The heating power of the gas would thus be very greatly increased, whereas if an open boiler were made use of the heat would be rapidly lost, and there would be a great waste in consequence. He had demonstrated the importance of this precaution in his own establishment, where he had a large shop 30 feet by 18, and 15 feet high, thoroughly well heated by the consumption of 10 feet of gas per hour. The boiler was enclosed in a box, and the products of combustion escaped from the sides of the box, which were perforated with holes. In reference to the heating of rooms by gas—dry heating—there was no doubt that if the system proposed by Mr. Hartley was adopted the best possible results would be secured—*i. e.*, by externally heating the air by means of gas, and conveying the fresh warm air into the apartments, instead of allowing the products of combustion to escape into the room. With regard to the ventilation of rooms where gas was used, there was a very simple mode of accomplishing it—viz., ventilation by diffusion. Dr. Macadam, in his lecture on the previous evening, had spoken of the power of diffusion possessed by gases. That power might be effectively utilized to secure the ventilation of rooms. By means of a diaphragm of muslin placed over a window or opening, this diffusion could be carried on. The porosity of the muslin would allow the heated air to escape more rapidly than the cold air could enter the apartment, and thus ventilation would be obtained without draught.

Mr. PATERSON (Warrington) said he could not sufficiently express the satisfaction he had felt with the reading of Mr. Hartley's admirable paper on a subject which had not yet received that attention from engineers its importance deserved. At an early date Mr. W. H. Palmer, of the Western Gas Company, found that a cubic foot of gas (the specific gravity of which was not stated) raised 20,000 cubic feet of air 1°. Taking this result as datum, it would be found that the relation of the heat capacity of air to that of water is as 1 to 4·17, and as 13 cubic feet of air was equal to 1 lb., then $20{,}000 \div 13 = 1540$, which, being divided by 4·17, gave 369 units by the combustion of 1 cubic foot of gas. Mr. F. J. Evans obtained from 1 cubic foot, having a specific gravity of 0·410, 650 units. Mr. Goddard, in his researches on the same subject, found that 27 gallons or 270 lbs. of water were raised through 145° by the combustion of 60 cubic feet, presumably about the same specific gravity, as it worked out to 652 units by the combustion of 1 cubic foot. The names of those gentlemen were a sufficient guarantee for the accuracy of any experiment which came from their hands; but the practical results were somewhat higher than those which he (Mr. Paterson) found on the ordinary application of the Bunsen burner to heating purposes. The details of those experiments were published in a scientific paper at that time, and it might prove interesting to tabulate the results:—

Abstract of Experiments on the Calorific Value of Gases under different Specific Gravities.

	Specific Gravity of Gas.	Cubic Feet = to 1 lb.	Units of Heat from 1 Cubic Foot by Calculation.	Units of Heat from 1 Cubic Foot by Experiment.	Decimal Proportion Calculated, Value as 1.	Water Evaporated in lbs. by 1 Cubic Foot.	Water Evaporated in lbs. by 1 lb. of Gas.	Decimal Equivalent of 1 lb. to 1-Horse Power — 33,000 as 1.
Boghead cannel. .	0·685	19·1	1213	558	0·485	0·595	11·27	0·323
Mixture of Boghead and Arniston. .	0·658	19·85	1224	588	0·480	0·595	11·81	0·354
Shale (Berwick) — sp. gr., 1·733 . .	0·650	20·33	1183	524	0·441	0·530	10·78	0·323
Mixed cannels . .	0·595	21·15	1114	544	0·488	0·550	11·64	0·349
,, gases . . .	0·440	30·14	886	472	0·533	0·478	14·40	0·431
,, ,, . . .	0·246	63·87	497	312	0·628	0·316	20·17	0·600
Hydrogen	0·0693	189·0	328	284	0·866	0·288	54·33	1·626
Anthracite, S. Wales	Best application, as used in steam-boilers.						10·70	0·320
Averages — 40 varieties, American coals							8·16	0·241
12 do., Lancash. do.							7·88	0·236
7 do., Newcstle. do.							7·86	0·235
7 do., Scotch do. .							6·66	0·199

These showed that the average evaporating powers of gas and water were as 1 to 2⅓. Mr. Goddard made it 1 to 3 nearly. Taking, however, the best practical results as adopted by Mr. Hartley, the heat lost by radiation and otherwise was so great that improvements were much needed in that direction, and in the practical hands of Mr. Hartley there was no reasen to doubt the application of gas to calorific purposes would not remain in its present unsatisfactory state.

Mr. WATSON (Sydenham) said Mr. Hartley's paper pointed out a way in which the mains of a gas company could become profitable during the daytime as well as by night. For his own company he could say that it was in that manner they had been able to bring down their unaccounted-for gas to something like 8 per cent. As to the economical aspect of the question from a consumer's point of view, he might state that on a recent visit to a house of 12 or 14 rooms he found most excellent heating apparatus in use, and on inquiry the occupier informed him that he heated the whole house and a bath included for something like 3d. or 4d. a day.

Mr. MAY (Canterbury) said at the present time, while fuel was so dear, it became very important that economy should be practised, so that all the heat obtainable from warming apparatus should be retained in the apartments, if possible. To effect this object with an ordinary open fire-place, he would suggest that the flue should be stopped just above the mantelpiece, and a wrought-iron flue 12 inches by 9 inches, in which were placed diagonally 2-inch circular tubes, open at both ends, and 6 inches apart, should be inserted. The lower end of the wrought-iron flue should be placed in the side of the brickwork above the fire, and carried inside the room to the room or rooms above, and turned into the brickwork flue at the top. As soon as the iron flue became heated, a current of air would be passing through the diagonal tubes, and the whole of the rooms would be warmed by the action of the one open fire. The same plan might be adopted with gas-stoves, a smaller flue being used.

Mr. BROADHEAD gave some details of the arrangements made by him for heating the offices connected with his works by means of gas. He had proved the economy of the process, but had failed in his attempts to get rid effectually of the products of combustion.

Mr. HARTLEY, in reply, said that he entirely agreed with Mr. Sugg in respect to enveloping a boiler with a non-conducting material in order to prevent waste of heat when it was desired merely to vaporize water or to raise the maximum quantity in temperature by the aid of gaseous or of other fuel, but such protection was not needed by any stove or boiler except such as

were not intended to give off their heat by immediate radiation and convecture. In instituting the comparisons which he (Mr. Hartley) had made, data had been taken which truly represented the maximum heating power which it had been found possible to obtain in practice from the bodies concerned. Mr. Paterson remarked that there was a vast difference in the published statements as to the heating power of coal gas. Such differences were not surprising, inasmuch as the heating power of any sample must necessarily depend upon the number or proportion of carbonaceous particles which the gas contains—the richer the gas in carbon the more heating power it will possess—and it would be found in the published proceedings of the association that, while one cubic foot of ordinary coal gas was stated to be capable of raising 650 lbs. of water 1° Fahr., the same quantity of cannel gas was put at 750 lbs., and these statements were quite concordant with his (Mr. Hartley's) experience. In so far as ventilation was concerned, he thought Mr. Sugg's remarks were a little beside the question. It was no doubt easy to obtain a free circulation of air, but when fuel, especially gaseous fuel, was being applied to the warming of rooms, it must be remembered that it was not desirable to have too free a circulation, as this would necessitate the consumption and waste of a large quantity of the material which was being burned for the purpose of producing heat. Mr. Sugg and Mr. Watson had both spoken of rooms heated by gas, but as he (Mr. Hartley) could not catch the figures named he could make no calculations on the observations to which he had listened; but he might state that the same amount of heat which would raise one pound of water one degree would raise about 50 cubic feet of air one degree in temperature. It was, therefore, easy to calculate what fuel should be required to make a room of given dimensions of a comfortable temperature. Mr. May mentioned a plan of carrying the flue of a stove into an upper room, and thus economizing heat. This might be a good plan under some circumstances, but the idea of warming two rooms, one over the other or adjoining, with one fire was by no means novel. In respect to Mr. Broadhead's observations, he (Mr. Hartley) might say that if a flue from a gas-stove were carried directly into the atmosphere, there would be at times great difficulty in getting efficient ventilation. As a rule, he thought that gas-stoves should be ventilated into chimneys. When possible, such stoves might stand in front of the ordinary fire-place, and the ventilating pipe should be carried some distance up into the chimney, while the fire-place opening should be, in respect to the room to be heated, hermetically sealed, otherwise there would often be a failure in ventilation. The closing of the bottom of the chimney would, besides securing upward draught, prevent the return of offensive vapours, and also the escape of large volumes of heated air up the chimney.

Mr. T. A. Skelton (London) read the following paper on

GAS STREET LIGHTING.

In treating the subject of the use of gas for street lighting before an association of practical men, able to bring a large amount of experience to bear upon the discussion which it is hoped will follow this paper, it is unnecessary to enter at any great length upon the introduction of gas as a means of street lighting; but, having briefly done so, I intend to submit to your notice these four divisions of the subject:—

1. The three means available for utilizing the light usually wasted in street lamps—viz., radiation, refraction, and reflection.
2. The catoptric lamp.
3. Lighting by rod.
4. Lamp supports.

These I will endeavour to illustrate both by diagrams and models. As you are aware, the use of gas for street lighting was first introduced into London in the year 1807, and the brilliancy of this new illuminating agent soon rendered the oil lamp an obsolete contrivance.

The earliest form of gas lantern was constructed with a metal roof. We have here a sketch of one of these from Lincoln's Inn Fields, London. These metal roofs were probably whitened on the inner side, with the object of throwing down some of the light radiating upwards, but, soon becoming discoloured, must have been ineffective, the only result being to prevent the

light illuminating the adjacent fronts of houses much above the level of the flame.

The first improvement in gas lanterns seems to have been that of glazing the roof, permitting the light to radiate in every direction (Fig. 1).

For many years, however, the mere introduction of gas for street lighting was a sufficient improvement to satisfy the public, then long accustomed to the faint glimmer of oil lighting, and so 40 years passed away without any attempt to improve gas street lamps by utilizing the wasted light.

The public had then become used to gas lighting, and probably comparing the brilliancy of indoor lighting with the feeble effect of open air lamps, were quite ready to complain of the insufficiency of the street lighting. Local authorities, of course, threw the blame upon the gas companies, and asserted that either less gas was supplied or that the gas itself was of a less illuminating power than they had stipulated for, hence followed disputes, and various expedients were resorted to for ensuring the satisfactory performance of contracts.

Now, while the illuminating power may still be a subject of discussion and complaint (often without reason), the question of quantity has been satisfactorily settled by the adoption of the ingenious apparatus called a lamp governor, now in very general use. Nevertheless, it must be admitted that the public are still unsatisfied with the present insufficient street lighting, and speak with just contempt of a system that wastes the effect of more than one-half of the gas they pay for.

But while the public complained, and the authorities disputed with the gas companies, inventors were actively if not successfully engaged in attempting to utilize more of the light actually produced, it being apparent that if the light now uselessly radiating into space could be deflected into a useful direction, a sufficient gain of illuminating power would be obtained without incurring the great annual increase of cost, which a larger number of lamps, a greater consumption of gas or a higher illuminating power in the gas would entail upon the ratepayer.

To effect such a desirable improvement in street lighting there exists only the three means I have mentioned—viz., radiation, refraction, and reflection. Of these, *radiation*, while the simplest in application, is the least effective, from the dispersion of rays which it effects. The best application of this principle is that of placing opal glass or thin porcelain in the roof of the lantern. In a lamp thus fitted, you will see by the diagram (Fig. 3) that the light radiating upwards from the gas flame impinges on the under surface of the opal glass, and is to a great extent radiated or reflected back into the lantern, and through it to the pavement directly underneath, and thus far the opal glass has the same effect as a white opaque solid roof. The opal glass or porcelain, however, allows some of the light to pass through its substance, and to radiate from its outer surface in every direction in front of its plane, so that a small, but in reality inappreciable quantity of the intercepted light reaches the pavement and roadway from this source.

Refraction has the power of directing and concentrating light, but in its application to street lamps requires to be used in combination with *reflection*, as it is powerless to deal usefully with the rays of light passing through the roof of such a lamp.

The disadvantages attending the use of this principle, apart from the expense and weight of glass lenses and prisms, are, that its greatest power is attained when the lens is placed in front of the light, so hiding the flame itself, and that it is least powerful where most required—that is, out of the direct line of light, say in the upper part of the lantern above the level of the flame. No application of this principle to street lamps has yet been successful, nor indeed does it seem possible that it ever can be.

Reflection being the most effective means for diverting or concentrating artificial light, its application to street lamps has of course been the subject of many inventions. The simplest form in which reflectors have been applied to gas lamps is the common concave or parabolic reflector placed behind the flame. In some lamps two gas flames are used with two reflectors back to back between them; examples of this arrangement may be seen in the railway stations in this city. They can, however, only be cited as illustrations of what to avoid in street lighting, where it is essential to leave the flame itself visible in every direction at and below its own level. Where metal reflectors have

FIG. 1.

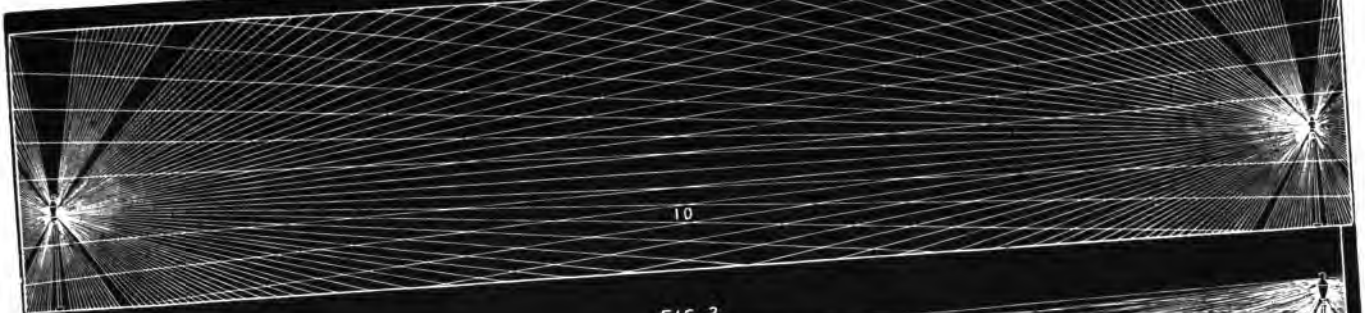

FIG. 2.

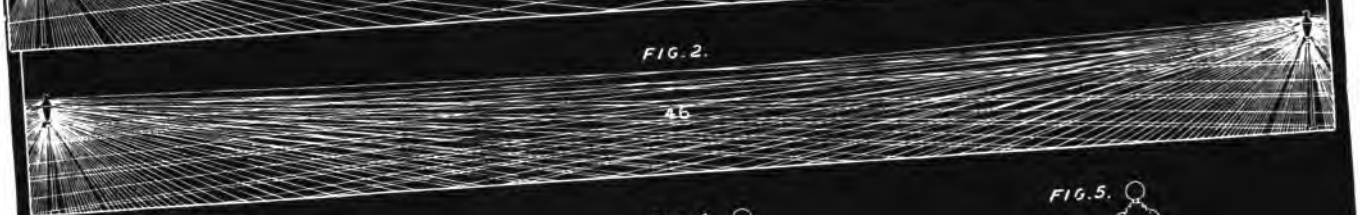

FIG. 3.

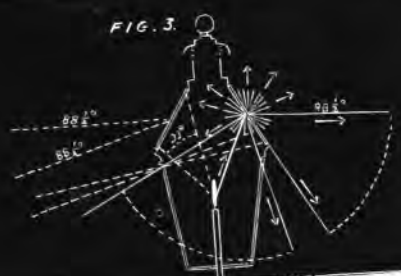

FIG. 4.

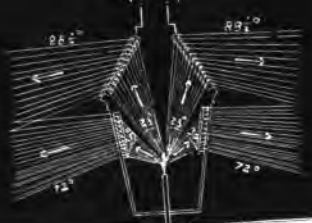

FIG. 5.

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been proposed as a part of the lantern, they have generally been some form of the solid roof with reflecting surfaces on the inner sides, reflecting the light back through the lantern, as shown in the diagram exhibited (Fig. 5), and concentrating it immediately below or close around the lamp, a large portion of the rays of light is reflected across the lantern top to the opposite reflector, and thence by a second reflection downwards to the ground underneath.

Through all this series of experiments with solid roof reflectors and their variations, there is firstly the defect of cutting off all light from the house fronts; and, secondly, the greater defect of concentrating what light they are capable of reflecting immediately under the lamp, where, with a moderate gas flame, there would already be sufficient light, and of leaving the darkest part of the road (the intervals between the lamps) not only unaided but actually darker than before, and comparatively much more obscure by the excessively uneven distribution of light.

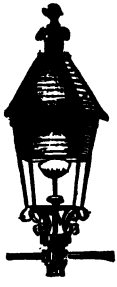
With such grave defects in all projected improvements in public lighting up to the year 1871, it is not surprising that local authorities were adverse to their adoption, and looked upon every new proposal as a merely fanciful variation of previous schemes which had already been tried and had failed, or gave no advantages equivalent to their cost.

It is remarkable that up to the year 1871 inventors had not succeeded in allowing the light to pass out from the lantern, merely diverting it in its onward course in a manner analogous to the action of the modern catadioptric lighthouse light, of which we have here a diagram, and as the reflectors would be somewhat numerous, and be liable to damage as well as be difficult to clean, also to enclose them between sheets of glass, which while protecting them would only offer the same surfaces for cleaning as the ordinary glazing of the common lantern.

These are the essential points in which the "Catoptric" lamp differs from all previous attempts to improve street lamps. Here we have specimens of these catoptric reflectors, which are thus easily and perfectly fixed in the lantern. You perceive that the light radiating upwards is no longer wasted, neither is it concentrated below or close to the lamp, but it is thrown forward, dispersed, or concentrated, as may be required along the usually dark interval between the lamps, making the pavement appear a "continuous ribbon of light," according to the graphic description given by the *Standard* of the first exhibition of this lamp upon Waterloo Bridge in October, 1871 (Figs. 2 and 4).

In application, this improvement is capable of almost infinite variety in detail, and it can be adapted to lamps of any form and size. Ornamental effects may be produced by the use of fluted glass or of coloured glass in various ways. Some common quick lime, enclosed within the cases, leaves no moisture to condense upon the inner surfaces of the enclosing glasses, but even without this precaution the power of the reflected light is but little impaired by such condensation, but for the sake of durability it is advisable to keep the cases dry, and air and water tight.

This specimen is the form in which this improved lamp is now manufactured —a simple 14-inch square street lamp. These cases of reflectors are easily removable, so that they may be replaced in case of damage without removing the lamp, and they can be readily repaired by any workman of ordinary skill. The gas flame must be placed at such a height that the top edge of the flame is just level with the bottom of the side reflector, and is thus visible in every direction at and below its own level as in a common lantern. Where attention has not been paid to this point, the effect of experiments with trial samples could not be satisfactory, as the flame would be out of focus with the reflectors.



The specimen cases I have here will be of interest, as showing the several improvements which have been made in the manufacture. This, one of the first pattern made, has actually been in use in the High Street, Southampton, for twelve months, and was then removed only in consequence of fracture of the outer glass by a stone, yet the silvered strips are uninjured. The improvements since made upon this pattern are shown in this reflector; it is thinner, the glass is secured in rebates without so large a putty-joint exposed. A screw plug allows the lime-tube to be removed and replaced, and the silvered glass

reflector-strips are coated with thin lead for ensuring durability and giving greater strength. With these improvements the reflectors may be considered perfectly adapted for general street use.

The lighting power of these catoptric lamps may be estimated by a reference to the diagram. Thus of the light passing through the 180° on each side of the vertical axis, about 10° are intercepted and lost by the disc of the lamp-governor; about 60° are given to the ground within a distance of 30 feet, and about 15° are usefully employed beyond that distance in lighting the road and footways, but the remaining 95° (more than one-half of the light produced) is usually wasted in the common glazed lanterns, except so far as adjacent houses may intercept a small portion.

Now, about 10° of this quantity is unavoidably lost by the necessary opening for the escape of the heated air above the flame, but 53° of the remainder are in this example of catoptric reflectors actually intercepted and diverted into the space previously illuminated by only 15° of direct light. With this great addition of lighting power, even after allowing for some loss of intensity by reflection, the darkness of the intervals between the lamps is practically overcome. I need hardly upon this occasion enter upon the subject of cost, further than to state that for ordinary street purposes the catoptric lamps will cost in first outlay about 20s. to 25s. per lamp more than common lanterns, and that the cost of repair will not be much, if anything, beyond the usual amount. If you are satisfied that a very considerable gain of lighting power *and a more even diffusion of light* are obtained by their use, their real economy will be apparent to you, without my troubling you with the details of the comparatively slight extra annual cost thereby incurred.

In the third division of the subject of this paper I may safely affirm that lighting street lamps by a rod is steadily gaining favour, and I venture to think that improved means of opening and closing the bottoms of lamps for this purpose, especially if it gives less shadow than the present system, will remove the chief difficulties which have hitherto retarded its general adoption. The plan hitherto has been to hinge one-half or one-quarter of the bottom glass of the lamp as a flap to be raised by the rod on its being thrust into the lamp, falling back to its place on the withdrawal of the rod. The result, in practice, is an increase of shadow under the lamp, and that most of the lamp bottoms are broken, after a short time, by the rod being roughly thrust through all parts, and the flame is at last exposed to the wind without any protection whatever, to its great loss in steadiness and lighting power.

The patented improvement I beg to introduce to your notice (of which a sample is fitted in this lamp) is that of a sliding or revolving quadrant of thick glass fixed to a bar encircling the gas-pipe at one end as a pivot, and having an arm of wire at the other, projecting beyond the square of the lamp. The bottom of the lantern is glazed with two thick pieces of glass, leaving an opening to be covered by the quadrant. The lamplighter opens and closes this space by striking the wire arm outside the lamp, hence breakage is almost impossible. This plan is now in use in Trafalgar Square in some catoptric lamps fixed there, and it is especially suited for those lamps as it permits the governors to be placed close to the bottom of the lantern.

The last division—lamps supports—is not an unimportant one, and a few words upon it may induce some gentlemen present to favour us with their experience upon the subject, two systems appear to be in use—firstly, the basket in which the lantern is suspended by its eaves; and, secondly, the bracket on which the lantern stands and is secured by nuts and screws attached to its feet.

The first seems to wear out the lantern by constant friction at its bearing, and the lantern is seldom seen in a perpendicular position, while the rods at the corners, and the broad flat lower bars, add very greatly to the shadows thrown upon the pavement and across the road. The second system—the bracket—seems to be the best, and is in general use where the lamps are of better than ordinary class. They are, however, too often heavy in design, and throw down large shadows under the lamp.

Wrought iron is better than cast for general street use, but where cast iron is preferred, the brackets should, I think, be made of thin plates edgeways to the flame, and utility should certainly take precedence of ornament in designing them.

These may seem almost trifling details, but to obtain perfect street lighting

too much attention to detail can hardly be given; and although here it may be unnecessary to insist upon so plain a fact, yet in many places it might be advantageous to explain that as gas is consumed in street lamps in order to light the streets, the light produced should not be wasted in the clouds, or be obscured by either dirty glass, thick bars, or heavy brackets.

Mr. GARNETT (Ryde) wished it to be quite understood, in any observations he made on the interesting subject of street lighting, that he bowed unhesitatingly to the admirable natural and scientific principles brought into play by Mr. Skelton in his invention. But he thought on an occasion like the present, when they were met for the purpose of deriving information from all sources, and seeing that, more or less, every member of the association had to do with local boards, corporations, and other public bodies who had to pay for street lighting, this was a subject which could not be too well ventilated. He therefore wished to bring under the attention of the meeting the Westminster lamp, an invention of Mr. Sugg. He (Mr. Garnett) resided at Ryde, in the Isle of Wight, and in that town there was a pier half a mile in length running out towards the celebrated roadstead of Spithead. Ryde was exposed to the full force of south-easterly and other gales, and such was the effect of these gales on the street lights that the gas company were sometimes asked for as much as £40 in the way of fines for lamps blown out. He was called upon by the authorities to light the pier, and, by means of the lamp to which he had referred, he was able to succeed in doing so to their entire satisfaction. The desideratum was a lamp which would reflect light upon the deck of the pier, and not be liable to be extinguished even in the strongest gale. In November and December last these gales prevailed to a considerable extent, and although during their continuance scores of lamps in the town were blown out, not one of those on the pier was extinguished or even wavered. The Westminster lamp reflected the light admirably on the deck of the pier, so that the rails of the tramway could be distinctly seen all the way along; it was easily cleaned, and there was an admirable method of opening and closing the orifice where the torch was introduced. He believed that some of these lamps had been fixed on the new pier at Beckton.

Mr. M. OHREN asked whether any photometric test had been made of the increased lighting power of the catoptric lamps.

Mr. SKELTON said a photometric trial had been made at Chatham Dockyard, under the Royal Engineer officer in charge of the works, and it was found that the equal intensity of light and shadow between two lamps, 60 yards apart, one being the catoptric and the other common, each having exactly the same flame of gas, was, at a point 20 yards from the common lantern and 40 yards from the catoptric lamp, which was thus proved to be throwing its light twice the distance, or giving equal to four times the illumination of an ordinary lantern. This trial was considered so satisfactory that he had since received orders to supply a number of catoptric lamps for lighting the dockyard at Chatham.

Mr. SUGG, in compliance with the wish of the president, then gave a description of the Westminster lamp, illustrating it roughly on the black board. He said: The Westminster lamp was octagonal in form, and was provided with a ventilator at top a little different to those in ordinary use. It was composed of two concentric cylinders, perforated with elongated holes; the cylinders were so arranged that the holes did not come opposite each other, and so the wind could not enter directly into the lamp and blow upon the flame; but after passing through the first or outside cylinder it struck the blank space of the internal one, and so was made to reverberate again into the air. The top was filled in with porcelain plates instead of glass. These served to reflect the light upon the ground round about the lamp, and prevent the upcast rays from being lost. Of course it did not direct them in the same manner as the more scientific reflectors of Mr. Skelton's lamps, but merely threw them on the ground round about the lamp-post. The porcelain tops were first introduced by Mr. Woodall, of Burslem. They were now made use of a great deal in South America and in Burslem, but not much elsewhere in England at present. The Westminster lantern differed from all others in the mode of fixing to the lamp-post. The glass bottom was an octagonal cone, and forms its own support, terminating in a gun metal socket which dropped into the top of the post, where it rested very firmly. The socket having been greased when the lantern was put into its place could at any time be easily

lifted out, although no force of wind would move it. It was lighted and extinguished with a torch, for which purpose there was a flap bottom, which was fastened by a very simple balance bolt. A touch from the lighting pole on this bolt caused the flap to fall open, and after the lamp was lighted the flap was closed by the pole, the bolt slipping into its place by itself, and preventing the flap from being blown open by the wind. These lamps were first made for Beckton pier, where they had been in use ever since the opening of the gas-works there. He was not aware they had been so successfully employed by Mr. Garnett, and begged to thank him for his kind remarks.

Mr. SKELTON said he did not for a moment look upon Mr. Sugg's lamp as a rival to his own. Indeed the object of each was different, and both lamps were useful for the special purpose for which they were designed. If in street lighting the lanterns could be put sufficiently close together so that the light thrown downwards was sufficient, no doubt that would be a far pleasanter and better way of illumination. But it was impossible in ordinary streets to get the authorities to go to that expense, and it was on this account that he had been induced to suggest the means now exhibited for throwing the wasted light into the dull intervals, and not below at all. Where the lamps could be arranged in such close order that the economy of these wasted rays was not of so much importance as a strong downward light, the invention of Mr. Sugg was an exceedingly useful and admirable contrivance.

The PRESIDENT, in proposing a vote of thanks to Mr. Skelton, said the invention which he had just brought under the attention of the association was a very ingenious one, and an illustration of the truth that wherever a man devoted his thoughts and intelligence to a particular subject, it generally resulted in the production of something highly ingenious and useful.

Mr. J. R. FRITH (Runcorn) read the following paper on

A PLAIN SYSTEM OF BOOK-KEEPING BY DOUBLE ENTRY, SPECIALLY ADAPTED FOR GAS COMPANIES.

The reasons which prompted me tc prepare a paper on this subject are the knowledge of the very imperfect way in which many gas companies have their books kept, and consequently the uncertainty of a proper return being rendered to the shareholders; a desire to assist those secretaries and managers who have a wish to secure an improved system of book-keeping; and, further, a longing to see the books of our gas companies placed on a sound basis, so that they shall not be subject to the remarks concerning them which have been made during the last few years.

When we read of a gas company with a capital of upwards of £370,000 working without (what one would suppose is in the possession of every respectable tradesman) a cash book, we cannot but express our astonishment and regret.

I am well aware in many gas offices a good system of book-keeping is carried out, at the same time I know in others there is neither system nor correctness; indeed, some of the books of gas companies which have come into my hands have been a source of annoyance and uncertainty to every one connected with them.

There are many who imagine that the system called "double entry" means double labour, and as many managers in country gas-works are secretary, engineer, manager, and almost everything else, and have plenty of duties to perform without, as they think, additional work, consequently do not take the trouble to inquire into the merits, and lose the advantage of a system which is beneficial to them in time and accuracy. To all who view "double entry" as double labour I would say a correct system is not so, but really less, and when done carries with it the assurance of truth and correctness. An old proverb says, "If a thing is worth doing, it is worth doing well;" and let the book-keeping of gas companies be no exception to this rule.

In arranging the accompanying accounts, I have endeavoured to combine brevity with clearness, so that any one having an ordinary knowledge of book-keeping may at once understand them.

I shall now endeavour to show what "double entry" means, and then attempt an explanation of the books required to carry out the system I now lay before you.

Double Entry.

Double entry is that mode of keeping books which always shows two accounts in connexion with each transaction; for instance, if the gas company sell coke to Wallace Bruce, there are two accounts affected thereby—first, Wallace Bruce is debtor for having received the coke, and coke account (or, in reality, the gas company) is creditor for having sold it. Again, if the gas company purchase coal, two accounts are in like manner required—first, coal account (or the gas company) is debtor for having received it, and the coal company is creditor, being the seller. In these examples you will see the reasons for the term double entry being used in contradistinction from single entry, where only one account is represented.

There are few commercial undertakings where so large a number of nominal accounts (such as the accounts for coal, meters, &c.) are required as in gas companies. It will be seen as we proceed how suitable this mode of book-keeping is to them.

The desirability of keeping each account distinct so as to show how much per 1000 cubic feet each department has cost, and, on the other hand, how much has been produced, is acknowledged by all companies, and looked upon as a necessity, without which no system of books can be complete.

The principal books required to be kept by gas companies are sales day book, gas rental, collectors cash book, cash book, journal, ledger, and balance book, and I will now endeavour to explain these in detail. There are other subsidiary books so universally kept as now to need no mention.

The Sales Day Book.

This book is for the entry of all goods sold, such as coke, tar, ammoniacal liquor, &c. (special books being provided for fittings and gas), and is ruled with three money columns; the first for coke, the second for tar, and third for sundries. There being few entries for ammoniacal liquor and other smaller sales during the month, it is not necessary to have separate columns for them.

The first entry is as follows:—

Day Book, folio 1.

Ledger Folio.	July 19, 1872.	Coke.			Tar.			Sundries.		
	Tims, Edward	£	s.	d.	£	s.	d.	£	s.	d.
	T. Cwt. Qrs.									
41	2 9 3 Coke . . at 7s. 6d.	0	18	8	0	0	0	0	0	0

which is entered from the machine book, and the amount carried out into the coke column, and so with the other accounts for the month. With such things as fittings used in branch pipes, and time laying mains, it is better to have a separate book for each, giving the particulars of all branches laid and goods used; also showing the length and size of each main, and the time occupied.

At the end of the month each column is added up, the particulars of the third (sundries) division are extracted, and the total of each account is entered at the end of the month's sales, thus giving the total amount of sales during that time; and each account is then entered at the foot to be journalized (see "Sales Day Book," folio 1).

The Gas Rental.

An able paper was read, and the form of this book was laid before the members of this association in the year 1865; and as the form of it resembles mine, I need not now dwell upon it, but mention a few alterations made to it in the form I lay before you.

1. It is made to last twelve months, or four quarters, "for once writing out the names."

2. I object to having more than one receipt column, because I consider there is greater liability to error with three columns than with one.

3. The "removals." When a customer leaves during the quarter, the particulars of his account are entered into the rental for the next quarter, as Joseph Simpson, who left and paid his account on the 30th of May, 1872.

The cash paid appears in the March quarter, but the particulars of the account appear only in the June quarter; and to balance his account there, it is necessary to write "transferred" in the date paid column, and enter the amount so transferred in the cash column. In order to balance the rental with "the collector" (ledger, folio 29), it is necessary to deduct what is termed the "over credits" from the arrears carried forward, which gives you, if the postings are correct, the balance required.

To balance the Dr. and Cr. columns, add the "over credits" to the amount of the Dr. column, and add the arrears carried forward to the Cr. column, and the Dr. and Cr. amounts agree as shown.

The Collector's Cash Book.

The collector when receiving an account for gas, &c., gives a printed cheque receipt, leaving a counterpart in the book upon which is the name of the customer, the amount paid, and the discount allowed. This amount is entered in the collector's cash book, where there are three columns—the first for gas-rents, &c.; the second for discounts; and the third for ledger or coke, &c., accounts.

This account should be made up weekly and the money paid into the bank, and I consider these entries should be frequently and carefully audited.

In posting to the rental, the total amount paid by each, including discounts, is entered.

The ledger accounts are copied into the cash book, to be posted with the other accounts received.

The discounts are journalized each quarter (see "Journal," folios 5 and 9).

If the postings from the collector's cash book are correct, the total of the gas-rents, &c., and the discounts, &c., for the quarter will agree with the total of the credit side of the rental, with the transfers from the previous quarter added thereto.

The Cash Book.

I think this book requires little or no explanation from me. All cash received is entered on the debit side, also all cheques drawn on bankers; and all payments made, including cash paid to bankers, are entered on credit side. Cash is thus debited for all cash received, and credited with all cash paid.

The posting of the cash book is direct to the ledger, and it must be borne in mind that all debit accounts in the cash book will appear on the credit side of the ledger, because, whilst the cashier has received money, and therefore debits himself with it, the party who pays it has to be credited for having so paid it.

I like the plan of posting direct from the cash book to the ledger, as it can be done at once, and therefore you can have the particulars of each payment posted daily, without waiting until the end of the month before journalising the cash, as is done by many who keep their accounts on the double-entry system. It also has the additional advantage of preventing errors in copying.

Different companies have a different way of dealing with their cashier. Some allow him to receive gas-rents, &c., and out of such moneys to pay wages, &c., paying the balance into the bank; others, again, prefer the gas-rents, &c., to be all paid into the bank as received—say weekly—and provide for wages and sundry expenses by a cheque. I have shown it the latter way, and therefore there is always a balance at the commencement of each month. At the end of each month the sum total of the cash on the debtor side is entered at the bottom of the page, and the amount of balance at the commencement of month deducted therefrom, thus showing the amount of money received, and then journalized thus:

		£	s.	d.	£	s.	d.
Fol. 1	Dr. Cash for cash received this month . . .	610	10	5			
	To sundry accounts posted from C. B. .				610	10	5

The same procedure applies to the creditor side, and the same plan is also adopted at the foot to show how much money has been paid during each month, and is journalized accordingly.

The Journal.

This is one of the most important books, and I think I am correct in saying one least understood.

All transactions, excepting details of sales day book and cash accounts, are first entered here before being posted to their several accounts in the ledger.

It will be obvious, from what has been already stated, that the monthly totals only of day and cash books are all that need journalizing.

You will observe there are two money columns on each page—the first, or left-hand column, is for the debtor accounts, and the other for the creditor accounts in each case.

The first entry in the journal is a transfer of stock to the coal and fitting accounts, because coal is debtor to stock at the commencement of the half year for the coal in hand; and the same remark applies to fittings, therefore it is entered thus:

				£	s.	d.	£	s.	d.
			Dr. Coal account.	10	0	0			
			,, Fittings	390	13	3			
			To stock of materials . .				400	13	3

Here let me observe that the debit accounts must precede the credits in each case, and the amount carried to the debtor or left-hand column, and be on a line with the posting account (in this case coal account), and must always commence with debtor; the same applies to the creditor side (or right-hand column), and the entries must begin with the word "To."

The two columns must be added up at the bottom of each page, and carried forward from page to page to the end of each quarter; and in no case must there be in either the debtor or creditor columns any amount other than the posting amounts. The totals at the end of each quarter will be found (if posted correctly) to agree with the totals of the ledger balance book, which will be hereafter described.

Several advantages are to be derived from keeping the debtor and creditor entries distinct; any error can be more readily discovered; there is less liability to make mistakes in posting the debits for the credits and *vice versâ*, besides which it is a complete check on the ledger.

It is necessary to observe the following rules in entering the journal:—

1. Enter the invoice for goods received according to their dates.
2. Any special transactions occurring during the month, as on Aug. 12.
3. The cash received and cash paid during the month.
4. The sales day book.
5. Discounts, &c., allowed during the quarter.
6. The rental for the quarter.

1. *The Invoices.*

Here we have an invoice for cannel received, and it is entered (see "Journal," folio 1):

				£	s.	d.	£	s.	d.
			Dr. Coal account (net amount)	50	4	9			
			To the Coal Company, J. B., No. 1 .				50	4	9

Coal account having received this amount is debited with it, and the Coal Company having sold it is credited with it. It will be observed here that the particulars of the invoice are not entered, but there is reference to the invoice book, No. 1, where the invoice has been pasted; and on referring to that number you have the invoice itself, without wasting time in copying it into the journal.

2. *Special Transactions.*

Here we have on Aug. 12 the half-yearly meeting of shareholders to declare a dividend, and a dividend of 10 per cent. is declared, which amounts to £1200; therefore this amount requires to be transferred from the dividend account (to which the profit for the half year has been carried) to the proprietors, as being dividend due to them (see "Journal," folio 3).

3. *The Cash Accounts.*

Cash is debited with the net total amount received, and is posted to a cash account in the ledger, folio 21, and sundry accounts are credited with the total amount paid to the cashier; and these sundry accounts having been regularly posted from the cash book to the ledger, are here ticked off, showing that they are already entered.

Totals of cash payments are also journalized in a similar way.

It will now be seen that the journal contains the aggregate amount of all cash receipts and payments, and the cash debits and cash credits in the ledger must agree with these. On reference to the balance of the cash book, Dec. 31, 1872, folio 7, and the balance of cash in the ledger, folio 21, the balance is the same.

4. *The Sales Day Book.*

Here, again, we have debtor sundry accounts posted from sales day book. The accounts have been daily posted to the debit of their respective accounts in the ledger, because these parties have purchased coke, &c.; but the respective nominal accounts require to be credited with the total sales, and therefore we say, "To coke." Observe these total credits agree with the total sales during the month.

From what has been said, the remainder of the entries in the journal will be clear until we come to the

Closing Entries.

The first item we have is the estimated amount allowed from profit and loss account to discounts to cover the probable amount which will be allowed on the December quarter's rental, which is put at 3 per cent., because we show the gross rental on the credit side; whereas that is not the sum actually to be received, but that amount less discount.

The next entry is for the transfer of all new investments during the half year to "Investment in plant."

We next transfer to the debit of "Profit and loss account" the whole of the revenue charges during the half year, and this balances the whole of the nominal accounts (say, coal, &c.); next we close gas-rental, &c., by transferring the balances of these accounts to the credit of profit and loss account, which is credited with all sales of gas and residual products during the half year.

The final entry is the balance of profit and loss account, which is the net profit for the half year, transferred to dividend account.

The closing entries having been posted to their respective debtor and creditor accounts in ledger, and extracted from the ledger to the balance book, the aggregates of the journal, ledger, and balance book must be alike, otherwise the postings are incorrect.

The Ledger.

I call this Ledger B, supposing there is a Ledger A, from which all balances are brought forward, to commence with the 1st of July, 1872.

In the ledger the accounts are ranged in the following order :—

1. The capital accounts.
2. The revenue accounts.
3. The creditor or tradesmen's accounts.
4. The debtor or sales accounts.

To give greater ease in posting and in extracting the balances, having all accounts of the same denomination following each other.

I have only shown one ledger, but where there are many coke, &c., accounts, it is better to have a separate ledger for them.

It is not necessary here to describe the manner of posting the ledger.

The Balance Book.

To show the correctness of the ledger, we have recourse to the balance book, in which are entered, first, the balances extracted from Ledger A, the debtor and creditor totals of which, it will be observed, agree; from that we find there is the same on the debtor side of the ledger as on the creditor side, and we also learn that the balances from the old ledger are correctly brought forward. We have finished with the balance book until the close of the first quarter, when all the debtor and creditor entries during that time (except the balances) are added up in red ink on their respective sides in the ledger, and are entered

in the balance book; and if the postings for the quarter are correct, they will be the same on the debtor side as the creditor side, and also will correspond with the total amount of the journal for the quarter ending the 30th of September; if it is not correct, it at once shows the postings to be incorrect, or the additions wrong, and they must be examined until the error is found.

This process is repeated for the trial balance at the end of the half year.

The second or half-yearly trial balance being correct, we enter the closing entries, which have been already fully described to you, and a reference to the book itself will show better than by description how easily the debtor and creditor general balance is arrived at, and how impossible it is under this system for any errors to pass or escape notice.

The Balance-Sheet.

As it is very important that a clear statement should be set before the shareholders at the half-yearly general meeting, I have prepared a balance-sheet which, at a glance, shows the working of the company for the six months; and if copies of this are sent to the shareholders, they can compare and see how the undertaking is progressing.

If I have omitted to mention anything, it is because I know most of you are acquainted with book-keeping, and therefore have endeavoured not to trouble you with unnecessary explanations.

I feel firmly persuaded that if this system was more universally adopted, it would save managers and secretaries much superfluous labour, and there would be less anxiety both on the part of the shareholders and managers.

Mr. GARNETT (Ryde) said, without attempting to enter upon the merits of single or double entry, there was one little matter suggested itself which he might mention. All present were agreed as to the importance of good book-keeping, though all perhaps might not agree in the special form now proposed. A short time since he was himself engaged upon an arbitration in reference to the transfer of gas-works by compulsion from a company to a local board. The accounts of that company, though kept by single entry, were so well kept that the opposition of the corporation was thus far disarmed, that their counsel were instructed not to challenge the company's accounts. The point, however, which he wished to mention was this—that a form of accounts was furnished in the Gas-Works Clauses Act, 1871, and he had no hesitation in saying it was unquestionably the very best set of accounts ever yet published. He was quite sure that if gas companies would adopt it, they need have no fear as to the result of any investigation of their affairs, either by a parliamentary committee or a court of arbitration.

At the conclusion of his paper, Mr. Frith exhibited a specimen set of books prepared on the double-entry system for a period of six months.

The PRESIDENT said the paper presented by Mr. Frith was an exceedingly suggestive paper, and would, no doubt, be read with great interest in the transactions of the Association.

Mr. RANDALL (Tottenham) read the following paper on

THE COMPUTATION OF GAS ACCOUNTS ARISING FROM THE NON-REGISTRATION OF METERS.

The writer submits this paper for the consideration of the members, feeling assured that the subject is of great importance, and one which every official would be pleased to have solved.

Computation from non-registering meters, according to the present system, is in a very unsatisfactory state, there being no established rule laid down for its regulation, every gas company adopting more or less a method of its own (considered by the consumer an arbitrary principle), founded upon the basis of a corresponding period's average consumption; which, it must be admitted, often leads to unpleasantness and dissatisfaction, and, to a certain degree, is unjust to the company.

Cases can be cited where affirmation has been made that, from a pure principle of economy, the number of lights has been curtailed since the 12 months preceding the quarter in which the meter has ceased to indicate, or certain rooms have been partially or wholly unoccupied. The consumer being a person of acknowledged integrity, the gas company (or its officials) placing implicit

confidence in the statement, cannot conscientiously insist upon an average of former periods. Again, on the other hand, the consumer has acknowledged to having increased the number of lights within a corresponding period (as stated above), and leaves the matter in the hands of the company to deal justly with. Also a meter has ceased to register within the first quarter of its being fixed, therefore there is no consumption to base the average upon. Now it must be acknowledged that in either of the above-mentioned cases the officials are placed in a sort of dilemma, and prepare themselves for a sharp contest in the shape of a paper war or discussion. The opponent may possibly be open to conviction upon the average principle, and acknowledge rather dubiously to an accidental derangement of the meter, which the company has endeavoured to rectify apparently in a spirit of justice; but there are others who declaim most vehemently against the desire of the company and its officials to take them at a disadvantage, preferring the interposition of the law courts to the system in use by some particular company.

There is no gas company, I am confident, that is desirous of the arbitration of what is ironically termed "justices justice," but would in preference, and do, in many cases, sacrifice to a conciliatory policy, well knowing that it is worth something to enjoy the confidence of the consumer if business is to be done pleasantly in the future. Therefore these facts, strengthened by similar cases which have come under my own observation, have induced me to attempt to lay before you the question of computation, in hopes that the discussion that may arise therefrom may take a practical form, and serve as a beacon for future guidance.

1. A uniform rule to be adopted by all gas companies, according to the number of burners, whether jets or Argands, admitted to have been in use during the quarter in dispute, and number of lighting hours, estimated at per burner. A burner to be tested for that purpose, and compared with average quarters of corresponding periods, or the consumption ascertained by meter for a given number of nights, and an approximation arrived at by simple proportion.

2. Computation unfair in cases where proof is shown that lights have been dispensed with entirely.

3. Computation unjust to gas companies where it has been positively ascertained that additional lights have been fixed.

4. Computation not applicable in cases of new consumers.

There are also cases where it is necessary to draw the attention of the meter manufacturers and the official meter inspector, the importance of which cannot be denied, and which can be vouched for as follows:—

The inspector for the company which I have the honour to represent has tested meters for non-registry, but finding that the test-dial has accurately recorded the quantity passed from the 5-feet holder, has refixed them with the same result of stationary indices at the subsequent quarter; also meters have been fixed working backwards to 9000 instead of 1000 feet, and 90,000 instead of 10,000, and so on *pro ratâ*.

Lastly. It cannot be too firmly impressed upon the minds of the official meter testers, in cases of disputed accounts, when their abitration is appealed to, the importance of furnishing the consumer with an accurate reading of the index, as we have had cases where the official in question has erred in 10,000 feet.

Much might be stated regarding the position which meters (either wet or dry) occupy, also the preference for dry or wet meters, with the view of reducing the number of non-registering meters to a minimum, but the title of this paper precludes the writer from entering into this branch of the subject.

It was the intention of the writer to have given a tabulated statement showing results of various tests made with non-registering meters, and the ultimate adjustment of the disputed accounts; but, as each official can produce cases from his own knowledge and experience, it would trespass upon the time of the meeting.

With these remarks the writer closes this somewhat crude and hastily prepared communication.

A vote of thanks was given to Mr. Frith and also to Mr. Randall for their papers.

The meeting then adjourned.

On the PRESIDENT taking the chair in the afternoon, he stated that the next paper on the *agenda* was one by Mr. Gore (London) on "Substitutes for Coal in the Manufacture of Illuminating Gas." In Mr. Gore's absence, the paper would be read by the secretary.

Mr. G. ANDERSON suggested that the paper should be taken as read, there being no person present to reply to any observations which its reading might elicit.

Mr. R. P. SPICE (London) said he must enter his protest against any paper being "taken as read," and afterwards published. It might be, and he had reason to believe it was in this case a fact, that there were observations of a very damaging kind in a paper so dealt with. If he were correctly informed, the paper of Mr. Gore's contained injurious remarks relating to a modern invention in which he (Mr. Spice) was concerned, and in which parties had invested a quarter of a million of money, and he thought it would be very wrong that those remarks should go before the world, infusing so much poison into the minds of persons connected with gas companies, without the opportunity being afforded to him to furnish the antidote. Without, however, at all entering upon that question at present, he submitted that if the paper was not read it should be withdrawn. He could not allow a paper involving the credit and reputation of persons who were not present to speak for themselves to appear on the records of the association, without it having been read. If it was read, he should have something to say upon it, and he should at once ask the president to adopt one of two courses—either have the paper read, or direct it to be withdrawn.

The PRESIDENT said he was about to remark, before Mr. Spice spoke, that he quite agreed with Mr. Anderson's proposition as a general rule, but inasmuch as the paper now under discussion contained a description of certain processes which certainly had excited considerable attention among gas proprietors and those having an interest in gas undertakings, the better way on the present occasion (as indeed he had previously suggested to the secretary) was to have the paper read, or at least such portions of it as dealt with those particular processes. Probably those parts of the paper which dealt with other methods and substitutes for coal might be omitted. But he must confess that Mr. Gore having sent in a paper of this importance, it would have been better for him to have made a point of being present, or, if that was not practicable, to have withdrawn his contribution. It was not for him (the president) to do so; it must either be read, or the meeting must deliberately resolve to take it as read, and print it afterwards. Surely, neither the writer nor those who were opposed to the views he represented could sustain any injury by the paper appearing in the records of the association. For his own part, however, he (the president) desired to have it read.

Mr. SPICE said if the paper were not read there would be no opportunity for discussion, and it would go forth to the world with all its errors unanswered, which he thought would be a most dangerous and unjust proceeding.

The question was then put to the meeting, and it was decided that the paper should be read.

The SECRETARY proceeded to read, but

Mr. G. ANDERSON interposed, and submitted that the meeting was going on irregularly. He did not know upon what authority Mr. Spice had made the remarks he had made upon the paper, but for himself he stood there in perfect ignorance of its contents. If Mr. Spice had any corns which were likely to be trodden upon by the publication of this paper, he would have abundant opportunity for retaliation after it was published. He contended that it was a perfect waste of time to read the paper, and that no reason had been adduced why the usual course should not be adopted.

The PRESIDENT said so much of the paper as had been read related to the manufacture of oil gas. Every one present knew about the patent which Taylor had for the manufacture of oil gas, and the manner in which it was carried out. There was nothing new in what Mr. Gore said on this point, and therefore this part of the paper might be passed over in order to come at once to that which related to the modern inventions now exciting so much attention.

Mr. JABEZ CHURCH rose to order, and maintained that the meeting had already decided to have the whole paper read.

The SECRETARY therefore, in the absence of the writer, read the following paper on

SUBSTITUTES FOR COAL IN THE PRODUCTION OF ILLUMINATING GAS.

By HENRY GORE.

The recent extraordinary advance in the prices of coals used in the manufacture of gas has induced several persons to turn their attention to the possibility of employing other substances than coal for the production of illuminating gas, and within the last 12 or 18 months a number of suggestions have been made, and not a few patents taken out for inventions, each of which claims to have discovered the means by which the desired end may be arrived at. The author of this paper proposes to lay before the members of the association a brief history of what has been accomplished up to the present time in endeavouring to produce illuminating gas from other substances than coal, pointing out in passing what he believes to be the comparative value of the several processes, and also endeavour to give some reasons why such processes have not come into general use.

Before, however, proceeding to describe the various contrivances that have been from time to time brought forward to supersede the use of coal in the production of artificial light, the author would beg to call attention to some conditions which are essential in estimating the value of any substance that is proposed to be employed to furnish light. These conditions may be broadly stated as follows :—

1. That by combustion of the body a sufficient degree of heat be evolved to maintain continuous combustion.
2. That, when the burning body is a solid, it can be easily converted into vapour previous to its complete combustion, as otherwise no flame is generated which is absolutely required for the purpose of illumination.
3. That the burning body evolve in the flame solid matter or very dense vapours, as an essential condition of the illuminating property of the flame.
4. That either the body itself or the raw material from which it is obtainable be present in large quantity and readily accessible.
5. That the products of combustion be gaseous and harmless to the health.

It is a generally known fact that any great accumulation of heat imparts to bodies the property of emitting light. This is more conspicuous in solid and fluid bodies, because their molecules are placed more closely together than is the case in gases and vapours; thus, at a temperature of 1000° Fahr. a solid body becomes red hot, at a little over 1800° white heat or perfect incandescence occurs; but a gaseous body heated to these degrees of temperature would only emit a very feeble light. In order to render a gaseous body luminous during its combustion, it should contain the vapours of some of the higher class of hydrocarbons, and that these, becoming white hot, should yield light. A combustible gas may be used to ignite solid matter accidentally placed within its flame, and thus produce light, as in the case of a coil of platinum wire exposed to the flame of hydrogen gas, or a cylinder of lime or magnesium in the oxy-hydrogen flame; but, as these lights can only be employed under very special circumstances, it is not necessary to include them in the consideration of the present subject. It is clear that for all practical purposes we can only avail ourselves of such materials for illumination as yield a flame which emits light in consequence of the vapours of heavy hydrocarbons present therein. These hydrocarbons are, indeed, contained in all the substances which are either used for illuminating purposes, or from which illuminating materials are prepared; as, for instance, tallow, palm oil, stearine, wax, spermaceti, paraffin, vegetable and animal oils and fats, mineral and essential oils, coals, shales, or bituminous schists, wood, and resins.

The recent investigations into the character and composition of luminous flames made by Helgard, Kersten, Delville, and Frankland have led to a considerable modification of the views previously held by chemists as to the precise form which the solid material assumes when undergoing complete combustion. Recent observations would lead to the supposition that the particles of carbon are not separated in a solid form as had been previously supposed, but that they are consumed in the shape of very dense vapours at the extreme outer envelope of the flame. This view seems to

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account for some of the phenomena which are observable when hydrocarbon vapour is burnt under the form of air gas, and has no doubt favoured the use of the more volatile vapours derived from the distillation of petroleum oils.

It would be impossible, within the limits of this paper, to make more than this passing reference to the recent researches relative to luminous flames, but the information to be derived from these researches is unquestionably of very great importance when applied in connexion with certain processes which have recently attracted so much attention—the "air gas" and the "new gas."

The substances from which artificial light has hitherto been derived may be divided into three distinct classes:—

1. Those bodies which are solid at ordinary temperatures, such as tallow, stearine, wax, paraffin, and spermaceti.

2. Fluid substances capable of burning in lamps, such as animal and vegetable oils, camphine or other form of essential oil, and the several varieties of mineral oils, or petroleum.

3. Gaseous substances, derived directly from the destructive distillation of coals, bituminous schists, peat, wood, resin, animal and vegetable oils, fats, and crude mineral oils; or by secondary processes, such as the so-called water gas obtained by passing steam over red-hot metal or charcoal, and then bringing the resultant gases in contact with substances rich in hydrocarbons; or, in another way, by passing currents of more or less dry atmospheric air over the surfaces of highly volatile hydrocarbon compounds, as in the case of the various forms of air gas.

The chemical constitution of illuminating gas may be stated to consist of three primary sets of compounds, as will be seen on referring to the following table:—

Constituents of Illuminating Gas.

Gases.	
Acetylene	C_2H_2
Elayl	C_2H_4
Trityl	C_3H_6
Diteryl	C_4H_8
Vapours.	
Benzole	C_6H_6
Styrolen	C_8H_8
Naphthaline	C_8H_{10}
Acetylnaphthaline	$C_{12}H_{10}$
Flouren	
Propyl	C_3H_7
Butyl	C_4H_9
Diluents.	
Hydrogen	H
Methylhydrogen	CH_4
Carbonic oxide	CO

We discard for the present purpose the impurities that are present in greater or less quantities in all gases derived from destructive distillation. First we have the luminous gases, next we have the hydrocarbon vapours, and then we have the diluents, or, as the German chemists very appropriately call them, the *light-bearers*. The substances, therefore, best adapted for the production of illuminating gas are unquestionably those in which the elements just mentioned exist in the proper proportion, and hence the value of cannel coal as a gas-producing material. Next to cannel coal come the several varieties of bituminous coal, and of substances other than coal. The oils, fats, and resins rank first, as being best suited for the generation of gas by destructive distillation; then we may take wood, peat, and vegetable refuse as substances capable of producing gas, but of inferior value, from the deficiency of luminous gas or hydrocarbon vapours.

Taking the substances in the order in which we have placed them, those which must first claim our attention are the oils and resins. The former seem to have attracted the attention of experimenters at a very early period in the history of gas illumination, for, by referring to the records of the Patent

Office, it is found that allusion is made to the generation of gas from oil so early as 1811. In 1815, Mr. Taylor, of the firm of Taylor and Martineau, obtained a patent for manufacturing gas from oil, and under modifications of this patent, gas-works were in operation at Bristol, Hull, London, Liverpool, Colchester, Dublin, and in several towns on the Continent. In conducting the process an iron retort was set over an ordinary furnace, by which it was to be heated. The retort was partially filled with fragments of brick, pumice-stone, or hard coke; above the retort was placed an horizontal cylinder or reservoir, or other suitable vessel, to contain the oil, and at the same time serve as an intermediate receiver for the gas and other products of distillation. The oil was made to trickle into the heated retort through a small tube near the front. Coming in contact with the heated surfaces of the bricks placed therein, a portion was speedily converted into gas or vapours; these latter, as they had to traverse the entire length of the retort, became in their turn converted into gas. This gas, together with any undecomposed matter, then passed into the oil cylinder through a pipe at the back of the retort. The permanent gas, passing afterwards through the cooling apparatus, and then to the gasholder, the undecomposed oil, vapours, and tar remained in the cylinder, and mixing with the oil, were again conveyed to the retort, and thus the process continued until nearly the whole of the materials were converted into illuminating gas. A gallon of oil yields about 110 cubic feet of gas of a specific gravity of not not quite 700. The illuminating power of oil gas varies considerably, depending in a great measure on the temperature to which the retorts are heated. The author had occasion to use oil as a substitute for cannel for some considerable time, and he found the heat which gave the best results was what would be called a dull heat in a coal gas-work. Owing to the unprecedented increase in the price of coals for export, it is very possible that oil will be substituted for coal in many gas-works on the Continent, particularly in the olive-growing districts of Spain and Italy, the refuse from the oil-presses making very excellent gas.

About the time that Taylor was engaged upon his experiments with oil, other parties were turning their attention to resin as a material from which illuminating gas might be made; several companies were formed and works erected, both in this country and abroad, especially in the United States and Canada. Resin has been employed as a source of illuminating gas in a variety of processes, but the author will confine his remarks to two—one in which the resin is subject to simple dry distillation in an ordinary retort, and the second, where resin is employed to enrich feebly luminous gases. Under the first type the apparatus employed was originally invented by the late Professor Daniel, for the Resin Gas-Works, at Bow. In an ordinary oven two circular retorts are placed, so as to be heated by the furnace below. These retorts pass through the oven, and are open at both ends. The front end of each retort is bolted to a plate, the end of the mouthpiece passing through this plate, and is closed by an ordinary lid, cottar, and cross-bar screws. Flush with the outer edge of the mouthpiece an iron frame is fixed, fitted with a pair of sliding doors. The frame and doors leave a space of about 6 inches between them and the brickwork of the oven. On the top of the oven, and immediately over the retorts, a tank or cistern is placed, and under the bottom of this cistern the heat from the oven is conducted on its way to the chimney. The back end of the retort extends about 9 inches beyond the wall of the oven, and to this end of the retort is attached a flanged mouthpiece, but the exit-pipe for the gas, instead of ascending as in coal-gas retorts, descends and communicates with a tank or cistern by means of a dip-pipe. This vessel occupies the place of the ordinary hydraulic main, the gas being conveyed from it through the coolers or condensers to the gasholder. There is no necessity for using purifiers with resin gas. The mode of working the apparatus is somewhat as follows:—The retorts being heated to a good cherry red, the resin, broken into small pieces, is placed on a perforated shelf, which occupies the upper part of the cistern placed above the retorts. The heat derived from the bottom of the cistern melts the resin, and it passes in a fluid state through the perforated shelf or sieve, and is allowed to flow down the two syphon tubes that are attached to the mouthpieces of the retorts, and placed within the enclosed space formed by the frame and sliding doors. The liquid resin passes into the retort by means of a slightly inclined trough or channel, and is thus made to fall on the surface of the red-hot lumps of fire-brick with which the retort is partially

filled. The vapours given off by the liquid coming in contact with the heated surfaces pass along the whole length of the retort, and a large portion of them are converted into permanent gas. The undecomposed vapour passes along with the gas into the cistern or reservoir by means of the descending pipe, from whence the permanent gas escapes to the gasholder, the residual vapours remaining behind in the shape of what is known as resin oil, which is pumped back into the resin cistern, where it acts as a partial solvent of the solid resin. In France and the United States, where resin gas has been more extensively employed than in this country, an apparatus, invented by a French engineer, named Chaussenot, has been worked with great success. It is more complicated than the one just described.

In 1867 the author was engaged in constructing works for the supply of gas to the city of Mexico. The original design for the works contemplated the use of coal, but the non-completion of the railway between the city and the seaport of Vera Cruz rendered it next to impossible to obtain a supply of coal at any reasonable price. The cost of land carriage between the port and the city being at the rate of 100 dollars, or £20 per ton. To meet the difficulties thus raised, an apparatus was designed by the author, in which either wood or water gas could be made and rendered of sufficient illuminating power by combining with it a portion of gas made from resin, or the mineral pitch called by the natives "chapapote," deposits of which occur in Sucatan and on the Isthmus of Tehuantefoce. The retorts were set over an arched furnace in the usual manner, with the exception that the area of the furnace was much larger, it being necessary to use wood for fuel. The retorts were circular, 13 inches in diameter, and 9 feet 6 inches long, open at both ends. At the front end they were fitted with mouthpieces and lids, but instead of ascension-pipes, the two lower retorts were connected by short elbow-pipes to the mouthpiece of the centre retort. On the top of the oven, and immediately over the centre retort, was placed a small iron tank for melting the resin, or holding crude petroleum oil. The back ends of the retorts were fitted with mouthpieces, the two lower ones having ordinary lids, with screws and cross-bars. The upper retort mouthpiece was closed by a flanged cover, to which was bolted a flange bend and pipe for the purpose of conveying the gas to the receiver or hydraulic main placed below the floor of the retort-house. In working the apparatus for wood gas, the two lower retorts were charged with a species of resinous pine called by the natives "Ocote." It is obtained by splitting up the stumps and roots of the pine trees after the main portion of the trunk has been cut down. (This wood yields about 11,000 feet of gas to the 20 Spanish quintals, equal to 2080 lbs. English, if carbonized at a bright red heat.) The gas from the two lower retorts was conveyed into the upper retort by means of the two elbow-pipes, where it underwent a further decomposition. It then escaped to the purifiers, and the illuminating power would average about 10 candles; but owing to the supply of ocote being very irregular, it not being possible to rely on the Indians who collected it, ordinary wood was oftentimes obliged to be substituted. This would only yield about 7500 or 8000 feet to the 2000 lbs., and of very feeble illuminating power. To meet this difficulty the upper retort was converted into a resin retort, the resin being supplied from the cistern above. The gas from the wood mixed with the resin gas gave an illuminating power equal to about 12 candles; but the gases thus generated required a very costly process of purification to free them from the excess of carbonic acid and pyroligneous acid derived from the wood gas. The difficulty of getting rid of the impurities just mentioned led the author to devise a means for using the gases derived from the decomposition of steam instead of the wood gas; but it being next to impossible to obtain suitable apparatus in a country like Mexico, a plan was adopted by which the wood retorts were made to serve the purpose for generating the water gas. In each of the two lower retorts a cast-iron tube about 5 inches diameter was placed. This was filled with scrap iron, and supplied with steam through a suitable pipe. Round this tube, and nearly filling the retort, was packed charcoal and lumps of native "Tysoutle," or pumice, a species of volcanic cinder found in almost every part of Mexico. The other arrangements were precisely the same as for the wood and resin gas, except that the gas was conveyed into an ordinary hydraulic main, and passed through condensers, scrubber, and a set of lime purifiers in the ordinary way. The mode of working the apparatus was as follows:—The steam entered the iron

tubes, or decomposing chambers, and a portion of it was converted into hydrogen by coming in contact with the heated scrapiron. The undecomposed vapour was converted into hydrogen, carbonic oxide, and carbonic acid, by the charcoal and pumice. These gases then entered the upper retort, where resin gas was generated, the mixed gases afterwards passing to the condensing and purifying apparatus; but the process had to be abandoned on account of the large quantity of carbonic acid present, and the great cost of its removal. The resin and wood process was ultimately adopted, and the city of Mexico has been supplied for the last five years with gas made from these materials. It will be in the recollection of most of the members of the association that the hydrocarbon gas, patented by Mr. White, was essentially a combination of water gas with resin gas; but the process, although tried under the most favourable circumstances at Rio Janeiro, never succeeded, although Boghead cannel was substituted for the resin. It appears that the only circumstances under which resin can be used with advantage for the generation of illuminating gas are where resin is cheap and wood for fuel abundant. In practice only about one-half of the weight of crude resin can be converted into gas. The residue is condensed in the shape of oil at a bright red heat. The quantity of gas for weight of resin actually converted will average about 850 lbs. per 104 lbs., or about 18,000 feet per ton English. The illuminating power of such gas will be about 14 standard candles. A very curious property the author observed in connexion with resin gas is, that when used by itself it travels with great facility, and does not lose its light-giving constituents; but if mixed with other gases, a deposit of a thick viscid substance takes place on the inner surface of the pipes and fittings, through which the mixed gases may have passed. To this cause may be attributed many of the complaints that were raised against White's hydrocarbon gas when it was first introduced.

The materials next in importance which have engaged the attention of experimenters in the manufacture of illuminating gas are the mineral oils, either in their natural state or as derived from treating shales or bituminous schists, and some varieties of asphaltes or mineral pitch. These substances, like resin, have been either used directly for the generation of gas, or have been used in combination with non-luminous gases. Within the last 10 or 15 years many patents have been taken out for processes or apparatus for the destructive distillation of these mineral oils, but up to the present time no process has been sufficiently successful as to secure for itself any general recognition. In Germany and the United States some of the attempts made to use crude petroleum have met with comparative success. The one which the author believes to be the best is the invention of a German chemist, Dr. Hertzel. The apparatus consists of a circular retort set in the usual manner. The retort is fitted with a mouthpiece and lid at each end. The front mouthpiece is connected to a large cylindrical chamber or receiver by a taper pipe, which is substituted for the ordinary ascension-pipe. At the back of the retort is placed a small cylindrical vessel or chamber fitted with a cover and stuffing-box. In the interior of the chamber a weighted piston or plunger is placed, the rod of which passes through the stuffing-box. To the upper end of this rod a cord is fastened, which passes over a series of compound pulleys, and the end connected with a train of clockwork machinery. From the bottom of the box or chamber in which the piston is placed a small tube or pipe is connected with the lid at the back of the retort, and from thence a small taper tube projects into the interior of the retort. The process of manufacturing the gas is as follows:—The chamber or cylinder in which the plunger is placed is filled with the petroleum or mineral oil until the plunger has risen to the top. The cord is then coiled over the pulleys, and the end attached to the clockwork. As soon as the retort is sufficiently hot, the pendulum of the clock is set in motion, and the cord is gradually uncoiled. This liberates the plunger or piston, and thus the liquid in the cylinder is forced through the small connecting-pipe and taper tube into the retort, where it is distributed in a very thin sheet over the heated surface. A considerable quantity of the vapour is thus converted into gas, and is coveyed by the large taper pipe into the vertical receiver. Here the gas and vapours are separated by the cooling effect of the receiver, the permanent gas passing to a suitable gasholder,

the condensed vapours, in the shape of tar or oil, fall to the bottom of the receiver, and are drawn off and returned to the first cylinder, when a fresh charge of oil is put in. The process is exceedingly ingenious, but the author is not able to say what the result of the experiment has been in a commercial point of view. In the United States many forms of apparatus have been tried, but most of them have failed on account of the great difficulty of getting rid of the rapid deposition of soot or solid carbon on the surfaces of the retorts, or the materials placed within the retorts to effect decomposition. It is found in practice that a comparatively thin layer of this finely divided carbon materially interferes with the process of decomposition, and the result is that when an apparatus has been at work for only a short time, it happens that the make of gas is reduced 50 per cent. If some arrangement could be invented by which this deposit could be prevented, there is no doubt that the mineral oils would be found most useful substitutes for cannel coal in the production of gas of high illuminating power.

Before entering upon a description of some of the processes in which mineral oils are used in combination with non-luminous gases, the author will briefly describe the system proposed for using wood and peat as gas-making materials. The use of wood for the manufacture of gas appears to have been suggested at about the same time as coal was being experimented upon. In the mechanical museum at Paris the author has seen the sketch and description of an apparatus invented in 1790 by a person named Lebon. It was evidently intended to compete with the invention of Mr. Murdoch, who was then engaged upon his experiments with coal gas at Redruth, in Cornwall. It does not, however, appear that Lebon's process was ever used beyond lighting his own house, as no mention is made of the introduction of gas lighting into France until 1815. After Lebon's invention, the first attempts to use wood for gas appear to have been made in Russia, but it was not until the experiments of Dr. Pettenkofer, of Munich, were made public in 1849, that any attention was given by gas engineers to the use of wood as a gas-making material. Since that time several cities and towns in Germany, Russia, and the north of Europe have been supplied with gas manufactured from wood.

In 1865 the author visited Germany for the purpose of making himself acquainted with the various processes then in operation for manufacturing gas from wood. He visited the works of Marburg, Darmstadt, Wurzburg, and Munich. The apparatus employed was the same as for coal gas manufacture, with the exception of one or two instances, where the ascension-pipes were cased and the hydraulic main was made double, leaving a space of two inches between the portion of the main into which the gas and products of distillation passed and the outer casing. The annular space between the two mains was filled with steam or heated air. It appeared that an essential condition for the success of the process was that the wood should be thoroughly dried or baked before being put into the gas-retorts, and that the temperature of the retorts should be maintained at a bright cherry-red heat. The illuminating power of the gas varied considerably, leading to the conclusion that in some instances a process of carburation was resorted to. An apparatus, designed for a town in the north of Russia, used the wood gas simply as a diluent, and made the illuminating power entirely dependent on its saturation by the vapours of naphtha. The apparatus used for carburetting has just been reproduced in this country by the patentee of the so-called "new gas."

The illuminating power of wood gas seems to depend very much on the quantity consumed. In practice it is found that a coal gas-burner consuming 5 feet per hour, and giving the light of 13 candles, will with the same consumption of wood gas only give the light of nine candles; but with a burner consuming 7½ feet per hour, the light from the wood gas will be 17·43 candles, as against 18·27 for coal gas. Mr. Riedinger, the engineer of the wood gas-works at Coburg, gives as the results of his experiments, that wood gas is 22 per cent. cheaper than coal gas, if the wood be taken before the essential oils have been extracted, and it is thoroughly dried before being subjected to distillation. The author found that by passing the gas through a second retort, heated to redness, the illuminating power of the gas was considerably improved. This is no doubt due to the decomposition of some of the oxides of carbon; but, unfortunately, the cost of purification was considerably

increased owing to the larger quantity of carbonic acid that was present in the gas. The author, however, believes that if suitable precautions be taken in thoroughly desiccating the wood, there are many localities where wood gas might be used with advantage, especially if lime be cheap and abundant. What has been said in reference to wood will more or less apply to the use of peat as a gas-making material. At the present time a series of experiments are being made with peat which has been saturated with the refuse of shale oil distillation; but as the details of the experiments have not been made public, no opinion can be formed as to the merits of the scheme. Several other processes have been suggested for using animal and vegetable substances in the manufacture of illuminating gas; but as none of them have been carried beyond the stage of laboratory experiments, it is not considered necessary to enter into any details respecting them. The author, therefore, now proceeds to review the plans that have from time to time been brought forward to produce illuminating gas by the admixture of non-luminous but combustible gases with some form of volatile hydrocarbon.

The possibility of utilizing the effect produced by the action of heated metal on water in connexion with the manufacture of gas appears to have been first suggested by the late eminent gas engineer, Geo. Lowe, Esq. In a letter written by that gentleman to the "Philosophical Magazine" of Nov. 14, 1818, he describes his experiments at Derby. In speaking of the use of iron tubes filled with scrap iron, and heated to redness, he makes this remarkable statement: "But by passing the tar and water of crystallization through iron turnings, or over any oxidizable surfaces, the two are nearly all converted into gas, and come over with the hydrogen of the latter, which *has been liberated at the expense of the iron turnings*, and to me it is evident the great increase *arises infinitely more from the decomposition of the water than of the tar*." Twelve years after the experiments of Mr. Lowe we have the patent of Mr. Donovan, of Dublin, and a year or two afterwards the process of Mr. Saunders. These, in conjunction with the process described in the patent of Mollerat, may be said to have been the foundation of all the subsequent inventions employed for the decomposition of water by passing its vapours over heated surfaces. It is true that the precise form of apparatus has been modified in accordance with the views of each particular experimenter, but the essential principles involved in the process are throughout the same. To describe the mode of manipulation in general terms, it would be somewhat as follows:—Two or more tubes or retorts are set over an ordinary furnace by which they can be heated to the required temperature. These retorts are partially filled with scrap iron, or in the case of several retorts being set together, one retort may be filled with scrap metal, and the remainder may be partially filled with charcoal or coke. As soon as the retorts are heated to the temperature required (which should be a bright red by ordinary daylight) a stream of water or steam is injected into the retort containing the metal. Here the vapour is to some extent decomposed, the oxygen of the water being taken up by the heated metal, which thus becomes rapidly oxidized. The other constituent of the water, the hydrogen, is carried forward, along with any undecomposed vapour, and enters the retort or retorts containing the charcoal or coke. And here a considerable portion of the remaining vapour is decomposed, the resultant gases being hydrogen and the two oxides of carbon, as carbonic oxide and carbonic acid; the gases, therefore, escaping from the last retort consist of partially pure hydrogen, carbonic oxide, and carbonic acid, with some sulphuretted hydrogen and traces of bisulphide of carbon, the two latter due to the sulphur derived from the coke and impurities in the scrap iron. The gases after leaving the retort undergo refrigeration, thus separating them from any undecomposed vapour. They then pass through suitable purifiers to remove the excess of carbonic acid and the sulphur compounds. The gases so purified are rendered luminous by bringing them in contact with the vapours of some volatile hydrocarbon. In the earlier experiments highly rectified oil of turpentine was employed; but the discovery of benzole, by Professor Faraday, led to the more volatile compounds derived from coal tar naphtha being substituted for the essential oils in the carbonization of what was called the water gas.

Illuminating gas made by the process just described was tried in several towns in this country, Ireland, and on the Continent, but in all cases resulted in signal failure, as it was found impossible to compete with the simpler pro-

cess of manufacturing gas from coal. About the year 1834 or 1835, considerable attention was drawn to a water gas process, patented in France by M. Selligue, in which a considerable modification of the decomposing process was adopted, inasmuch as the water vapour was conducted first into vessels or retorts containing charcoal, where it was converted into hydrogen and the oxides of carbon; in a third retort the gases so formed came in contact with the vapours of shale oil, and as this retort was nearly filled with iron chain or scrap, a considerable decomposing surface was exposed, and a large quantity of very superior gas said to have been obtained. But on subjecting the process to strict chemical investigation, it was found that some questionable proceedings had been had recourse to in carrying out the first experiments; when the chemist's report was presented the whole affair collapsed. From 1835 to 1849 a great number of schemes were brought forward, and some patented for improvements in the manufacture of water gas, but none appear to have succeeded. In 1850 a new process was brought forward by an American inventor named Paine. He proposed to generate pure hydrogen from water by the aid of a magneto-electric machine, and convert it into illuminating gas by passing it through camphine. The most marvellous results were claimed for this invention, and a monstre apparatus was prepared for the Great Exhibition of 1851, but the author believes that owing to the matter having been placed in the hands of Mr. Faraday, the fallacy of the so-called invention was exposed, and nothing more was heard of it. The well-known process of Mr. White for the production of hydrocarbon gas was at this period before the gas world, but as it resolved itself ultimately into a modified coal process, it will not be consistent with the object of the present paper, to make more than this passing allusion to it.

The enormous increase in the production of hydrocarbon oils, due to the discovery of the oil and petroleum springs on the continent of America, has given fresh impetus to the class of inventions which seek to substitute these oils for coal in the manufacture of gas. The direct destructive distillation of these oils has already been alluded to, but the utilization of the highly volatile vapours derived from the process of distilling these oils for general purposes has revived the idea of generating combustible gases by the decomposition of steam or water vapour. Of the several so-called inventions of the last four or five years, the only one which appears to present any new features is the one claimed by a Frenchman named Du Motay. It was originally intended as a process for the production of hydrogen to be used in connexion with the oxyhydrogen light, but in its modified form is being used in producing illuminating gas from hydrocarbon vapours.

The process may be described as follows:—Superheated steam is injected into a large retort or decomposing chamber filled with charcoal or coke, and heated to redness; here the vapour or steam is converted into hydrogen and carbonic oxide. From this mixture the carbonic oxide is removed by passing the gases through cylinders of hydrated or slaked lime heated to redness. The result of this treatment is the formation of a fresh equivalent of hydrogen, and the conversion of the carbonic oxide into carbonic acid by union with the oxygen of the decomposed water of hydration. The carbonic acid is removed by passing through more lime, and the hydrogen is passed on into another chamber, where it comes into intimate contact with a quantity of light petroleum spirit; here it loads itself with the vapour of the hydrocarbon, and continues on its course, passing next through a series of iron tubes heated to a low red heat, whereby a permanent gas is formed, precisely analogous in all its properties to the ordinary coal gas, but of considerably higher illuminating power. This invention has recently been in operation in the United States, and very favourable reports have been given as to the results, but no reference is made to the question of cost.

One of the old processes for manufacturing water gas has just been repatented in this country by a Mr. Ruck, who claims for it the title of the "New Gas," but in what the novelty consists it is difficult to discover. In this process it is proposed to use superheated steam, and the manipulation is somewhat as follows:—A bench of three or more retorts up to nine are set in, more or less, the ordinary manner. Alongside the top retort (which is considerably larger than the others), and within the oven are two cast-iron tubes or pipes, connected by an arch-bend, which passes over the top of the retort. If three retorts are set, this tube, or tubes, are made to communicate with the two

lower retorts by means of cast-iron pipes and suitable connexions to a pipe which lies along the bottom of each retort inside, and extending to within a few inches of the back of the retort. From the mouthpieces of the bottom retorts two branch pipes lead to pipes which lie along the bottom of the top retort, also to within a few inches of the back. The two bottom retorts are partially filled with scrap iron, or pieces of chain, mixed with a portion of coke or charcoal. The top retort may also be partially filled with coke or charcoal. Communicating with the flange-pipes alongside the top retort a steam-pipe from any ordinary steam-boiler is fixed, capable of being closed at pleasure by means of a stop-cock or valve. The retorts being heated to the required temperature, steam is admitted to the flange-pipes, where it becomes superheated. In this condition it passes to the two lower retorts through the pipes laid along the bottoms, and, escaping at the back of the retort, it then comes in contact with the heated metal, or charcoal, or coke, and a portion of it becomes converted into hydrogen and the two oxides of carbon. These gases, with the undecomposed vapour, then pass into the top retort through the branch pipes just described, and a further decomposition takes place. The resultant gases are then cooled and purified from sulphuretted hydrogen, and a small portion of the carbonic acid is taken out, and the mixed gases then are made to bubble through a quantity of light hydrocarbon spirit contained in a closed tank. This part of the apparatus is identical with the carburetting arrangement of the Russian wood gas previously described, but in order more readily to volatilize the heavier descriptions of petroleum spirit a current of warm air or steam is conveyed to the spirit-tank to maintain it at a suitable temperature. From the description just given it will be evident that the principle of the process is identical with all the previous inventions, so far as the means employed for the decomposition of the water vapour is concerned. It is true the patentee lays considerable stress on the use of superheated steam, but it is very questionable if there is any real importance to be attached to this part of the process. The intrinsic value of any of these inventions rests in the quantity of combustible gas that can be generated by the consumption of a given weight of fuel, and as the quantity of hydrogen to be thus obtained is the point of principal importance, it will be evident that the greater the weight of water decomposed by a given weight of fuel the more valuable the process becomes. For every 9 lbs. of water completely decomposed 180 cubic feet of hydrogen will be liberated. The proportions of carbonic oxide and carbonic acid will, however, vary according to the heat at which the process is carried on. The quantity of water gas produced by the consumption of a given weight of fuel varies considerably with the nature of the fuel employed. From a great number of experiments made by the late T. G. Barlow, Esq., the quantity of coke consumed per 1000 feet of water gas was found to average 60 lbs. In the author's experiments at Valparaiso, using the coke from a mixture of Australian and native coal, the average was found to be 73 lbs.; with charcoal, 104 lbs.; and with ordinary wood fuel, 127 lbs. per 1000 feet; and these are the results of experiments extending over several months. Mr. Barlow, in some instances, found that retorts making more than 600 feet per hour when first put into action gradually reduced in make to 352 feet per hour, and the average of a day's working was sometimes not more than 330 feet per working hour. Increased wear and tear occurs, due to the rapid oxidation of the interior of the retorts. This effect was fully shown in Mr. White's hydrocarbon process, and has been confirmed by all subsequent experimenters. The average duration of a water gas-retort is about 210 days, where a combination of scrap iron and coke or charcoal is used; but if scrap iron be used alone, from 170 to 180 days will be the maximum duration of such a retort.

Another important matter which requires consideration is the purification. It has already been shown that water gas is always contaminated with a very large quantity of carbonic acid, and more or less sulphuretted hydrogen, the latter increasing where coke is used instead of charcoal in the decomposing retorts. Supposing the process of purification be by lime, then the cost must be very great, because, from the greater affinity which caustic lime has for carbonic acid than for sulphur, it is obvious that the lime would absorb all the carbonic acid before it acted at all on the sulphur, and the removal of the sulphur compounds would depend on the amount of caustic lime left after all the carbonic acid had been taken up. If oxide of iron be used without lime, then the carbonic acid would remain, and of course materially diminish the

illuminating power of the gas. It is suggested by the promoters of the "new gas" that the presence of carbonic acid might be commercially disregarded in estimating the value of the process, but in experimenting with gas made in the manner proposed, it is found there is a loss of nearly two-thirds in illuminating power when the carbonic acid remains in the gas. The same class of spirit burnt in combination with pure hydrogen gave 31$\frac{3}{10}$ candles, with unpurified water gas only 11$\frac{7}{10}$ candles. The deduction the author draws from these facts is that the cost of purification must always form an important element in estimating the value of any water gas process.

If the description here given of the so-called "new gas" be a fair one, it is evident that such a process can never come into competition with coal, except under very special conditions; in fact, the circumstances would be so exceptional that they can never occur in any country where coal is the staple source of fuel. In some countries, perhaps, where wood fuel is abundant, and petroleum or other mineral oils easy to obtain, it is possible such a process of obtaining illuminating gas might be successfully applied; but under the most favourable conditions such a process would have to contend against the disadvantages inherent to the use of a manufactured material instead of a raw one, and the risks of interruption in supply, or the certain loss that must always take place in storing such volatile materials as these light hydrocarbons are.

Proposals have recently been made to construct a special class of steam vessels to convey to this country the kind of spirit it is proposed to employ in some of these hydrocarbon processes. The model of a vessel is now being exhibited in London, fitted with tanks having a capacity for many thousand gallons of the spirit. By a very ingenious arrangement of floats and valves and spare tanks, the effect of expansion due to variation of temperature is provided for, and all risk of explosion avoided, although the tanks are hermetically sealed. A company has been formed in the United States to provide the necessary apparatus and store tanks for collecting this highly volatile spirit, and it is assumed that a quantity equal to about 200,000 barrels will be collected during the year. Supposing the whole of this material to be shipped to England, the quantity available for the manufacture of illuminating gas, after allowing for loss in transit and other contingencies, is estimated at about 7 millions of gallons—a quantity sufficient to manufacture about 400 million cubic feet of 24 to 25 candle gas.

The author now proceeds to a partial consideration of those processes in which air is to be made the vehicle for conveying the combustible material for the production of illuminating gas. This idea was suggested many years ago by the late Mr. Beale, of East Greenwich, and Mr. Wm. Maugham, the well-known lecturer on chemistry. The whole of the apparatus was contained in a portable lamp, but it was found so difficult to manage, and the smell from the naphtha vapour so disagreeable, that the invention never came into general use. Some years afterwards, the late Mr. Mansfield took out several patents for lamps in which a current of air was drawn through a reservoir filled with benzole, and thus became saturated with the hydrocarbon vapour; the air thus charged was then consumed like ordinary gas. During the exhibition of gas apparatus held in 1851, several contrivances were shown for carburetting air; one, the invention of an American engineer, was frequently explained at the lectures given at the Polytechnic Institution. In 1854 the author made a series of experiments with an apparatus patented by a Mr. Longbotham, of Leeds. This invention consisted of a pair of bellows set in motion by a small steam-engine. The current of air from the bellows was forced through or over pumice-stone saturated with oil of vitriol so as to render it thoroughly dry; it was then driven into a vessel containing highly rectified coal tar naphtha and bezole, in which gum resin had been dissolved; the air when saturated with the vapour then passed into a gasholder, from whence it was conveyed to burners in the ordinary manner. In the course of these experiments it was discovered that air gas requires burners with very large apertures to burn it properly, for any undue pressure causes the vapour to separate from the air. Another matter was the fallacy of the test of permanancy. By simply allowing the gas to remain at rest in a gasholder, the same gas tested from the gasholder showed scarcely any loss of illuminating power; but after passing through 120 feet of pipe, it was found to have lost nearly 20 per cent. Another circumstance to which

attention was drawn is perhaps worth mentioning; it was that the deposition of hydrocarbon vapours increases with the quantity of gaseous material passing through a given length of pipe. This appears to arise from the want of homogeneousness in the structure of the vapours themselves. If air or combustible gas saturated with these dense vapours is made to pass through a long length of pipe, at first only a very slight deposit will be observed, but in the course of a short time a film of viscid matter will be found to have collected on the inner surfaces of the pipes; this film gradually increases, and after a time it will be found that a considerable quantity of liquid has accumulated from the vapours retarded by this viscid film. Gas engineers are all more or less acquainted with the effect produced by similar viscid deposits in the formation of naphthaline in coal-gas mains. In 1866 the author visited the United States, and while there had the opportunity of seeing a variety of processes for the carburetting of air; these were called gas machines. Most of these machines have been reproduced in this country under one title or another. Within the last six or eight months, nine patents or proposals for patents have been brought forward, based on the principle of saturating air with highly volatile vapours, but as they all involve the same general character, they all possess the same inherent defects—namely, want of permanency or danger of explosion. The former defect is due to the variable character of the oil or spirit used for carburetting the air. The higher the specific gravity of the spirit, the more unstable are the vapours. The author has found some samples that would give off vapour freely at a temperature of 60°, but would deposit 40 per cent. of their volume if the temperature were reduced to a little above 45°. As the specific gravity of the spirit becomes lower, of course the vapour is given off at a correspondingly lower temperature; in fact, in some samples of spirit with which recent experiments have been made, the vapour was found to be permanent considerably below the freezing point of water. The danger from explosion appears more to arise from the want of a proper quantity of vapour in the air than from the direct explosive property of the spirit itself. In the United States, where the most serious accidents have occurred, the causes of explosion have been shown to be the excess of air, either from the undue escape of spirit from the saturating vessel, or the effect of sudden and intense cold in checking the evaporation of the spirit, or, as has been the case in several instances, the adulteration of the spirit with a portion of heavy oil. But the risk of accident has become so great that a police ordinance has been promulgated at the instance of the American Insurance Societies prohibiting the use of *gasoline*, as this spirit is called, except in conformity with certain special regulations, such as the following:—"That no reservoir containing the spirit is to be allowed to be placed above the ground. That no such reservoir is to be placed within a distance less than 30 feet of any dwelling-house or enclosed building. That no reservoir is to be filled with gasoline after sunset or before sunrise. That no reservoir is to be made of any material but metal, and to be capable of being hermetically sealed."

One of the most recent modes of producing air gas is by making use of the weight of these vapours to induce saturation. A vessel containing some fibrous material is saturated with the hydrocarbon oil. To the lower end of this vessel a pipe is attached, terminating in an Argand burner with stop-cock. On the top of the vessel an aperture is made that can be closed by a metal cap. When the light is required the cap is removed, and the top of the burner is opened, a current of air is drawn through the saturated material contained in the body of the vessel by the descent of the heavy vapour, and on applying a light to the burner a very rich gas flame is produced. This arrangement is said to be the invention of Professor Greenhous, of the United States, who claims to have discovered a means of rendering these light oils non-explosive, Some startling experiments have been exhibited, but the author is not quite sure that the results were due to any special chemical preparation, or to the dexterity of the manipulator. If Professor Greenhous has discovered any method by which the volatility of these substances can be controlled, there can be no question but that he has conferred new value on these hitherto dangerous bodies.

In bringing this paper to a conclusion, the author would observe that he has purposely avoided any allusion to processes in which the distillation of coal enters, because he felt that the mere mention of the list of inventions embracing the partial use of coal in combination with some form of hydrocarbon

would have extended the subject beyond all ordinary limits; he has, therefore, confined himself to the consideration of such materials and processes as could be employed in the production of illuminating gas without the use of coal under any form whatever.

And now, without for one moment disparaging the efforts of those who from time to time come before the public with suggestions for improving the manufacture of gas, either by simple destructive distillation or by a combination of chemical processes, he believes he is warranted in coming to the following conclusions:—

1. That no material or process invented or brought forward up to the present time can compete with coal in the manufacture of illuminating gas, except in countries or localities where coal cannot be obtained.
2. That the substances most suitable for the manufacture of gas are those from which it can be obtained by direct distillation, as in the case of oils, resins, and woody fibre.
3. That no process of gas manufacture can be considered successful where the resultant gases are not readily purified, or where, after ordinary purification, they contain an excess of substances injurious to animal life.
4. That no mere carburetting process can be commercially successful until some form of hydrocarbon is discovered that is perfectly homogeneous in its chemical structure, and that can be rendered sufficiently non-explosive as to admit of its being transported from place to place or stored with comparative safety.

Mr. R. P. Spice said he would occupy as little time as possible in the few remarks he should have to make, and generally he might sum up that part of the paper which related to what was called "new gas," as in fact the whole paper might be described, as a list of failures in the direction of making gas companies independent to some extent of coal. Now, so far from viewing it as an objectionable matter or point to aim at, he held that it was desirable in the present state of affairs in the coal trade that gas managers *should* endeavour to seek some relief from other quarters, and so far as he was concerned this had been one of the motives by which he had been guided. He had felt that if water gas could be made at less cost, and of equal quality as far as light-giving properties as coal gas, a benefit must needs be conferred upon gas companies whether at home or abroad. When he first proceeded to inquire into the subject he had little idea that it could be of much value to gas companies in England, but he thought that if a permanent gas was procurable in this way it would be a great advantage to those engaged in foreign undertakings where coal was not easily procurable. But when he found that he could make 18-candle gas from water, with the aid of coke and petroleum spirit, at a cost of 1s. 8d. per 1000 cubic feet, it dawned upon him that while gas coals cost nearly 30s. per ton, and gas therefore of the same quality must cost 2s. 6d. per 1000, he might here find his way to the practical working of something that would be of value to gas companies at home. He had met with nothing in the whole course of his subsequent inquiries which had shaken his conviction in the correctness of that conclusion. He held in his hands reports of what was now being done with this gas on a practical scale at the present time in the city of Chichester, and he would read the reports of the superintendent there, dated the 23rd of May and the 7th of June.

The following are tests taken at the office of the City of Chichester Gas Company with gas now being supplied to the city, being about two-thirds spirit gas and one-third coal gas:—

Burning Four Feet per Hour.

London Argand burner	15·50	candles.
No. 6 brass fishtail	11·25	,,
Adamas No. 6	10·75	,,
Leoni's patent British Standard, No. 6	11·50	,,

Burning Five Feet per Hour.

Sugg-Letheby Argand burner	18·75	candles.
No. 6 brass fishtail	14·00	,,
Adamas No. 6	12·50	,,
Leoni's patent British Standard	14·75	,,

May 23, 1873. Robt. Church, Jun.

Water "Gas," tested at Chichester Gas-Works, June 7, 1873.

Argand.	Fishtail.	Fishtail.
Sugg-Letheby.	No. 8. Bray's.	No. 6. Bray's.
5 Cubic Feet per Hour.	5 Cubic Feet per Hour.	4 Cubic Feet per Hour.
18 candles.	13·5 candles.	7·75 candles.

EDWARD THORMAN, Jun., Superintendent.

Now this gas was being supplied daily in varying proportions to the city of Chichester, not because the company could not supply it in its simple purity, but because they found it convenient to make some portion of coal gas so that they might have coke produced on the works for use in their water gas retorts. And he might here state that it had been his view all the way through that gas companies would find the "water gas" process useful as a supplementary process while coal was dear, and not as superseding their ordinary mode of manufacture. And his idea was this, that a coal gas company might in many cases find it convenient to make just so much coal gas as would suffice to obtain the requisite quantity of coke, and to use that gas in combination with water gas. At one time the water gas was supplied in Chichester entirely, but this difficulty was found, that with the common fishtail burners in use there, as in many other places, such good results could not be obtained as with the mixed gases. But there was no difficulty in finding suitable burners; they were to be picked up anywhere, and certainly as regarded Chichester there had been and was no failure in the "water gas" system. So far as Mr. Gore's allegations were concerned, the best and most conclusive way of dealing with them was to let Mr. Gore answer himself. He would read a letter addressed by Mr. Gore to him (Mr. Spice) and Mr. Joseph Quick, who asked his opinion on the subject. They attached some importance to his opinion, having been informed of his experience in the manufacture of water gas in the city of Mexico and in Valparaiso.

Gentlemen,—In reply to the questions you have submitted for my consideration, I beg to report as follows:—

In reference to the first query, as to whether I consider it commercially practicable to produce an illuminating "gas by generating hydrogen, or any combustible but non-luminous gas, and afterwards saturating such gases with the vapour of petroleum or other hydrocarbon oils or spirit."

To this question, I beg to say that such a process is practicable as a commercial undertaking, supposing that the following conditions are complied with:—First, that the gases generated are permanent and non-condensable; and, second, that the saturating or hydrocarbon vapour is of such a character as to be capable of remaining suspended in the gas or gases at all ordinary temperatures. The class of vapour required can be obtained from almost any description of hydrocarbon spirit, the specific gravity of which does not exceed 680°.

With regard to the experiments made by Messrs. Joseph Quick and Son and Mr. R. P. Spice, I believe them to be perfectly trustworthy so far as regards the illuminating power of the compound gas, and also as to its permanency when exposed to considerable variations of temperature and the effects of friction in long lengths of pipes.

In respect to your second question—"That of the possibility of an illuminating gas, generated in the manner proposed, being used as a substitute for ordinary coal gas"—I am of opinion that the compound gas could successfully compete with coal gas as a source of artificial light, in situations where gas coal is expensive and difficult to obtain; in such localities, gas manufactured in the way you propose, might be introduced with advantage, because non-luminous gas may be generated from a variety of materials, such as wood, peat or turf, and other vegetable matter, or by the decomposition of water by the action of charcoal, or anthracite coal. The gases obtained from any of these substances can be converted into an illuminating gas by being saturated with the vapours of any suitable hydrocarbon. The compound gas could be most successfully employed for artificial light in warm climates or in countries where the temperature is comparatively uniform, and where wood is generally abundant.

As regards the comparative value of "air gas" and the gas manufactured by the process now under consideration, I am of opinion that the advantages are infinitely in favour of the latter. The so-called air gas consists in nothing more than the use of a current of atmospheric air to convey the highly volatile vapour of hydrocarbon spirit to a gas or other suitable burner where it is to be consumed. The air does not assist in the combustion of the vapour at all; consequently, a considerable portion of the spirit is expended in generating sufficient heat to ignite the particles of carbon from which the light is to be evolved; whereas, in the gas made by your process, the heat necessary for perfect combustion is obtained from the gas itself, and the hydrocarbon vapour is consumed under circumstances the most favourable to furnish the maximum amount of light which it is capable of giving. The want of permanency in the so-called air gas is fatal to its use as an ordinary means of illumination. Experiments have shown that any considerable reduction in temperature is invariably attended by a corresponding loss in illuminating power. The union between the lighter permanent gases, such as hydrogen,

marsh gas, and carbonic oxide and hydrocarbon vapours, is more intimate than between atmospheric air and such vapours; consequently, there is less liability for the compound gas to be affected by change of temperature or friction.

Air gas being nearly of the same specific gravity as the surrounding atmosphere, cannot be conveyed through pipes or tubes without the exercise of considerable propelling power; it is therefore next to impossible to employ air gas as an illuminating agent over extensive areas. The compound gas can, like coal gas, be conveyed to a considerable distance, the specific gravity of the two being nearly the same.

Many other reasons might be given in favour of the gas you propose to manufacture as compared with the so-called "air gas," but those adduced will, I think, prove amply sufficient to show the superiority of the one over the other, both as regards its physical constitution as well as its value as a commercial enterprise. HENRY GORE.

9, *Islip Street, Kentish Town, Dec.* 28, 1872.

But in the face of this Mr. Gore concluded his paper with a sentence like the following:—

"No material or process invented or brought forward up to the present time can compete with coal in the manufacture of illuminating gas except in countries or localities where coal cannot be obtained."

Surely he must mean his remarks as a joke. It was in effect to say that two horses were to run in a race, but one would have no chance except the other was kept at home. He (Mr. Spice) would only, in conclusion, refer to a report which had been received from Dr. Louttit upon the supposed poisonous character of the gas of the New Gas Company as compared with ordinary coal gas. The experiments were tried upon rabbits, which, at the present moment, were alive and well after partaking of a considerable portion of this gas in the state in which it was delivered to the public.

Experiment No. 1.—Bell jar filled with a mixture of coal gas and air—1-12th coal gas, 11-12ths air—rabbit put in; result as follows:—15 seconds, eyes twitching; 30 seconds, breathing hurriedly; 1 minute, breathing hurriedly, eyelids rapidly twitching; 1½ minute, dropping of ears, with slight convulsive movements; 2 minutes, continuation of the same; 2½ minutes, increased convulsive movements, moving about in jar; 2 minutes 45 seconds, sitting quietly in jar; 3 minutes, the same; 3½ minutes, the same; 4 minutes, breathing very hurriedly; 4½ minutes, moving in jar, pupils dilated; 5 minutes, suddenly became collapsed and comatose. The rabbit was then removed out of jar, and recovered as follows:—In 1 minute 10 seconds, gradually recovering, breathing quietly; 2 minutes, pupils beginning to dilate, breathing normal; 3½ minutes, moving about, but with a little difficulty; 5 minutes, recovered; running about looking but little worse for the inhalation of the gas, No sign of paralysis.

Experiment No. 2. — Bell jar containing a mixture of water gas and air — 1-12th water gas, 11-12ths air—rabbit put in; results as follows:—30 seconds, no perceptible result; 1 minute, moving in jar; 2 minutes, lying quiet, no convulsions; 2½ minutes, becoming comatose, slightly convulsed; 3 minutes, lay down in jar, breathing hurriedly; 3½ minutes, quiet, partially comatose, but now breathing quite normal; 4 minutes, twitching of lips and tongue (not protruding); 4½ minutes, the same; 5 minutes, the same; 10 minutes, comatose. The rabbit was then removed from jar, and recovered as follows:—In 1 minute, pupils contracting, breathing becoming normal; 2 minutes, moving head about; 4 minutes sitting up, there has been *no* paralysis of hind extremities; 5 minutes, the rabbit had entirely recovered, and appeared in no way hurt from the inhalation of the gas.

Experiment No. 3. —Bell jar containing a mixture of coal gas and air—quarter coal gas, three-quarters air—rabbit put in; result as follows:—5 seconds, screaming; 1 minute 15 seconds, strong convulsions; 1 minute 25 seconds, collapsed to bottom of jar; 1 minute 30 seconds, comatose, with convulsions; 1 minute 45 minutes, completely comatose. The rabbit was then removed from jar, and recovered as follows:—In 45 seconds, breathing hurriedly, paralysis of hind extremities; 2 minutes, breathing becoming normal; 3 minutes 30 seconds, sitting up and recovering; 5 minutes, moving about; 8 minutes, quite recovered.

Experiment No. 4.—Bell jar containing a mixture of water gas and air — quarter water gas, three-quarters air—rabbit put in; result as follows:—28 seconds, slight convulsions; 33 seconds, convulsions; 45 seconds, the same; 1 minute, comatose; 1 minute 52 seconds, completely comatose. The rabbit was then removed from jar, and recovered as follows:—In 30 seconds, began to exhibit symptoms of returning animation; 45 seconds, sitting up on hind legs; in 3 minutes, running about, quite recovered.

Experiment No. 5.—Bell jar containing a mixture of coal gas and air—half coal gas, half air — rabbit put in; result as follows:—3 seconds, screaming; 12 seconds, pupils contracting, eyelids moving spasmodically; 15 seconds, ears dropping, gasping for breath; 30 seconds, convulsions; 34 seconds, fallen to bottom of the jar, all the extremities perfectly paralyzed, back doubled; 1 minute, screaming faintly; 1 minute 5 seconds, completely comatose. The rabbit was then taken out of jar, and recovered as follows:—In 6 seconds, convulsive twitching of all extremities; 12 seconds, the same; 20 seconds, perfectly comatose, breathing normal, slight convulsive movements, pupils dilating and contracting, extremities still partially paralyzed; it remained in that state until the

expiration of five minutes, when it began gradually to recover, and in a quarter of an hour was sitting up, but did not shake off the effects for fully half an hour.

Experiment No. 6.—Bell jar containing a mixture of water gas and air—half water gas, half air—rabbit put in; result as follows:—30 seconds, convulsions; 45 seconds, fallen to bottom of jar; 50 seconds, lying quietly at bottom of jar and breathing hurriedly; 1 minute 10 seconds, perfectly comatose, paralysis of *hind* extremities only. The rabbit was then removed from jar, and recovered as follows:—In 30 seconds, breathing in short gasps, screamed faintly; 45 seconds, continued screaming slightly, pupils dilated; 1 minute, breathing hurriedly; 1 minute 30 seconds, eyelids rapidly twitching; 1 minute 45 seconds, ears twitching; 2 minutes 45 seconds, breathing quite normal, opening and closing eyelids, still partially paralyzed in hind extremities; 5 minutes, moving; 10 minutes, attempted to sit up, but failed; 18 minutes, sat up, animation returning; 20 minutes, running about; at the expiration of 30 minutes there was no apparent paralysis of hind extremities, and the rabbit appeared perfectly well and hearty.

The jar used in my experiments was a bell-shaped glass jar, about 2 feet high and 1 foot in diameter. The rabbits were healthy young ones about three-months old. The experiments were performed in presence of Mr. Sharp, my assistant, and several superintendents of Mr. Ruck's works at Greenwich. I think that I have proved conclusively that carbonic oxide gas in presence of hydrogen is, at least, not more poisonous that carburetted hydrogen gas. These rabbits were the subjects of frequent experiments, were soon after, and now are gambolling about as healthy and strong as if they never were the innocent recipients of the debated poisonous properties of the two gases. This subject is a matter of extremely interesting scientific investigation, and can be performed by any one capable of conducting the experiments properly.

Greenwich, May 20, 1873. JAS. LOUTTIT, M.D., M.R.C.S., &c.

P.S.—Since writing the above, I am glad to see in the JOURNAL OF GAS LIGHTING of the 3rd of June inst., that, in reply to a very able paper read by T. Wills, Esq., F.C.S., before the Society of Arts, Mr. H. P. Stephenson said that "Messrs. Frankland and Wright made experiments some years ago in order to ascertain the effect of carbonic oxide upon animal life as compared with the effect of ordinary coal gas. They experimented upon two rabbits of about the same age and weight, and the results of their experiments were that carbonic oxide is not more poisonous than ordinary coal gas." I am glad to be able to confirm the accuracy of the experiments made by the above-named distinguished gentlemen, and also to prove that carbonic oxide, either alone or mixed with air in varying proportions, is not more poisonous to animal life than ordinary coal gas in the same proportions. J. L.

June 6, 1873.

A considerable mistake had been made on this subject. He (Mr. Spice) had taken the opportunity to ask Dr. Odling, and afterwards Dr. Frankland, "Do you see any objection to the use of this gas as a means of lighting ordinary apartments?" Dr. Frankland's answer was, "None whatever," and Dr. Odling's, "Not the least."

The PRESIDENT said if it were convenient to Mr. Spice he was sure the meeting would be interested to have some details supplied as to the cost of this gas. Mr. Spice had spoken of the cost as 1s. 8d.; but what the meeting would like to know was, the quality of coal used in producing a given quantity of gas, and also the amount of fuel, and the quantity of hydrocarbon employed, the labour, and, in fact, a practical statement of the cost of producing the gas. He thought there was a general impression—and certainly he had been led to that impression himself from experiments he had made—that no process had yet been described by which hydrocarbons could be combined with hydrogen after both had been volatilized by destructive heat.

Mr. SPICE said he had none of the figures before him, but he thought he could furnish the information desired from memory. With regard to coal, they used no coal at all as coal; they used only coke; and water, and iron, and spirit. Those were the elements with which they had to deal. The water was converted into steam, and that steam was passed through a superheater, fitted in the same oven containing the retorts in which the gas was to be manufactured. It was then passed through a set of retorts, whether three, or five, or seven, from one to the other, so as to effect its perfect decomposition, but practically it was taken finally through a single retort. The operation up to this point was effected by the use of iron, steam, coke, and water. Each retort with which he had operated contained 1½ cwt. of coke and 1 cwt. of iron. One ton of coke put in and worked off, *plus* the steam, would produce 132,000 cubic feet of gas. To effect this he found it requisite to employ 2 tons of coke in the furnace, therefore there were 3 tons of coke employed to produce 132,000 cubic feet of gas. What the labour was, and what the wear and tear amounted to, he did not at the moment remember; but all things included came to about 7d. per 1000 cubic feet of gas produced, estimating the value of the coke at 20s. per ton. This was for the first portion of

the process. Having passed the gas through a condenser and a washer, constructed after the fashion of Coffey's still, it was passed through a purifier containing oxide of iron, by which all the sulphurous products were taken out. It was then found that the combined gas consisted of hydrogen, carbonic oxide, and carbonic acid. The quantity of the latter was about 10 per cent, and the illuminating power of the gas with this per centage was from 17 to 18, and sometimes 19 candles. The cost was brought up to 1s. 8d. by taking the cost of the spirit at 8d. per gallon, which he had been assured by those interested in the undertaking was a price quoted as quite the outside cost, and 1½ gallon was required for each 1000 feet of gas. His experience in the matter led him to conclude that in this respect he had been rightly informed. He believed they would be able to obtain pure spirit at that price. With regard to the difference between 7d. and 1s. 8d., there was an odd penny somewhere for some little attention to the apparatus. The two divisions of the sum were 1s. 1d. and 7d. In conclusion, he wished it to be understood that he was not present in the interest of any set or clique, and that he knew of no interest in this matter opposed to the interest of the gas companies throughout the country. He would also add, that he had always considered the interests of gas consumers and proprietors as identical, and it must be so. The prosperity of the companies depended upon that of those whom they supplied, and this must extend throughout the whole process, and apply equally to both systems.

Mr. Kelsall (Ashton) asked what kind of spirit was employed in the operation, and where the New Gas Company succeeded in getting it at 8d. per gallon.

Mr. Spice said it cost 13 cents f.o.b. at Philadelphia. He was not sure what the price at the well was, as this was not a matter which came under his care. The company depended upon Mr. Ruck, the oil refiner, as to the source of supply, and this had been the subject of inquiry by the board of directors. They had actually bought the oil, and had now a cargo on the way, at 13 cents, which meant 6⅛d. f.o.b., and when all expenses were paid on to their wharf on the Thames the cost would be 8½d. or 8¾d. per gallon. There was about 25 or 30 per cent., depending upon the character of the spirit, which was drawn off at a low heat, of the specific gravity of 650 to 680. This gas was an admirable carrier, but it would not carry more than 680. If tried beyond that it was like handicapping a horse till he was broken down. He had tried the experiment with oil of 690°, and had had to pump the spirit out of his gasholder syphon. Anything below 680 would travel any reasonable distance. He had gas still in store which was made in the month of October last, at Mr. Ruck's factory at Greenwich, which had been shut up in a 5-foot experimental gasholder during last winter, and was good now. He knew that the union between the hydrogen and the hydrocarbon was not chemical but mechanical; still it was an exceedingly good union, and lasted long enough for all practical purposes, and he ventured to say that the gas produced by this process was as permanent as coal gas. He had tried it after it had been shut up for 24 and 48 hours and even a week, and found it had a much better illuminating power than 20-candle coal gas would have had when so tested. The specific gravity of the gas varied from 518 to 525. He had found it a little less than that.

The President said he did not understand what quantity of hydrocarbon was required for the 132,000 cubic feet of gas spoken of.

Mr. Spice said he found that 1½ gallon of spirit, such as he had described, would saturate, in round numbers, 1000 cubic feet of gas—964 cubic feet was the exact quantity on two occasions. He had made the experiment with "air gas," and found it required 2½ gallons. He had passed the water-gas through a freezing mixture, putting it in at 60°, and taking it out at 33°, and found that it made no difference in it, whereas the so-called "air gas," put in at 60° and taken out at 40°, was found to have lost 33 per cent. of its light-giving power.

The President said there was one other question. It seemed from Mr. Spice's statements that about 200 gallons of oil were required for the 132,000 cubic feet of gas. What remained? what residuum was there?

Mr. Spice said he had never worked off the entire quantity; one reason for not doing so was that they found with the spirit, which cost them 8d. as they received it, when they had rectified about half, the residue was worth more than it was before.

The PRESIDENT: Better have it all residue.

Mr. SPICE said he did not mean that what was bought for 1s. was sold for 1s. 6d., but that what they took out left the residuum 700° or 720°, and in the market that heavy spirit had a value which the lighter spirit had not. The light spirit was only valuable for this gas-making purpose; but the heavy spirit had a value beyond the original rate of cost. They were now in treaty for the sale of the residuum at 1s. 0½d. per gallon.

The PRESIDENT: And you have taken that into consideration in making your estimate up to 1s. 8d.?

Mr. SPICE: That is part of the consideration.

Mr. JABEZ CHURCH thought the members of the association might congratulate themselves on having had the paper read, for he thought of all places in which the "new gas" was introduced, this surely ought to be the principal. He recollected that at the last meeting they had the opportunity of discussing the "patent gas," and they had a very eloquent description given by Mr. Mellor, who treated the matter in the most fair and gentlemanly manner. The opinions expressed on that occasion by the members of the association he (Mr. Church) thought had been fully borne out by the results of the last year's working. He was bound to confess that he himself was not converted to the "new gas," but he thought they ought to hail all inventions with great satisfaction, and give to the inventors every encouragement to develop their processes. There certainly never was a time when inventions to produce illuminating gas without the use of coal were more needed than at the present, and as gas companies were situated in England, he thought such inventions would be more useful here than in any other country. But the merits of this "new gas," in common with all other inventions, must be determined on commercial principles, and it appeared to him difficult, if not impossible, to arrive at anything like an estimate, except such as must be entirely conjectural, as to the cost of this gas. For this reason, in the first place, the petroleum spirit was of little value at the present time, but if it came to be generally used for gas-making it was only fair to conclude that the price would rise immensely; secondly, at the present time coke in gas-works was a common residuum, and its value was not very great, but if no coke was produced in the manufacture of gas that article would become very dear; and, seeing that large quantities were required in the production of the "new gas," it was difficult to imagine the price to which it would rise. Then, again, there was the heating material for the furnaces; he believed Mr. Spice had not mentioned whether coal or coke was used for the purpose.

The PRESIDENT: Coke.

Mr. CHURCH: Seeing that no coke would be obtained in the manufacture of gas by this process, here would be an additional source of expense. In forming a judgment upon the probable commercial success of the invention these elements were of considerable importance. Taking also what Mr. Gore said to be true, that the wear and tear of the iron retorts was excessive, that, looking at the high price of iron, was no unimportant matter. And after all came an element which must not be lost sight of, though, perhaps, it was more a matter for chemists to determine; but, as far as gasmen had been educated in chemistry, they had always looked upon carbonic oxide and carbonic acid as very detrimental to the light-giving properties of gas, and very injurious to the atmosphere in which such gas was burned. It was without any disparagement to Mr. Spice that he ventured to throw out these remarks; indeed, the name of Mr. Spice being associated with the process was to him a guarantee to some extent of the *bona fides* of the invention.

Mr. HARTLEY said his name having been mentioned by Mr. Spice, he would ask leave to make a few observations upon the subject before the meeting. His connexion with the scheme was this. Mr. Spice, after having engaged his services in relation to an air gas scheme (which experiments proved to be of an unsatisfactory character), asked his co-operation in making experiments on this new-old invention. He (Mr. Hartley) had had some experience in reference to water gas when Mr. Wright was associated with other gentlemen years ago in investigating the scheme of Mr. Gillard, therefore the process was not unfamiliar to him; and he might say that he started on his recent investigation with the full conviction that the whole thing must be a radical failure. In the first place he had believed, as an indispensable necessity, that every particle of carbonic acid

must be removed from the gas, and therefore that the process would be very expensive in respect to the cost of purification. But, to his astonishment, when he came to make experiments, he found that the removal of carbonic acid by actual purification was not necessary for the production of illuminating gas. Furthermore, he was completely surprised to find that the gas made by this process, after if had passed through a long coil of mains laid in an open field, possessed practically, at the end of that main, an illuminating power equal to that which it possessed previous to passing through the mains. In the face of such evidence as this, and after having seen the manufacture of the gas continued for some time, he felt himself bound at last to give the testimony which was published in the prospectus of the company. The practical working of the process had of course yet to be determined. With reference to the introduction of the scheme at Chichester, he had not been associated with Mr. Spice in that city except to the extent of supplying certain apparatus, but he had been there, and was delighted one night to see the whole of the streets lighted with the new company's gas pure and simple. Since then Mr. Spice had told the meeting that he had found it desirable, for the sake of coke production, to supply the town with a mixture of this gas and coal gas. He (Mr. Hartley) could only say that he wished the scheme success in its practical and commercial issue, because he felt assured that if it were so it would materially serve the interests of the gas world. He had heard very little of Mr. Gore's paper, and could do no more than express his surprise at the apparent antagonism evinced to the new company's process. It should be distinctly known and understood that when the scheme was under experimental trial he had urged Mr. Spice to seek the advice and assistance of Mr. Gore, believing, as he (Mr. Hartley) then did, that Mr. Gore's experience would be of great value. Mr. Gore received from Mr. Spice and from himself every possible information—every known detail—in respect to the working and the results attained, and afterwards Mr. Gore voluntarily wrote the document which was published in the prospectus of the new company. Under these circumstances, he (Mr. Hartley) could not but be astonished when he afterwards found Mr. Gore making an effort to recant. Whatever reasons Mr. Gore had for altering his opinion it was impossible for him (Mr. Hartley) to surmise; but it was a singular and startling fact, that having expressed an opinion favourable to the scheme, Mr. Gore had afterwards tried to discredit it, when it was about to be worked commercially, and when, moreover, a disclaimer, however sound or otherwise, was too late to serve any useful purpose.

Mr. G. W. Stevenson said he thought it was only fair to an absent man that he should call attention to the fact that so much of Mr. Gore's report as had been read went only to a comparison between "new gas" and "air gas." He did not at all understand that Mr. Gore withdrew his allegiance, so far as it had ever been exhibited, from the "new gas" scheme, although when he said that new gas was better than air gas it sounded somewhat as though he damned it with faint praise. He (Mr. Stevenson) thought Mr. Spice must have been a little misunderstood if it was assumed that he stated the cost of 132,000 cubic feet of new gas to be £16. There must be some discrepancy somewhere, because that would make the prime cost nearly 2s. 6d. per 1000. With reference to the invention altogether, he had only to remark that it seemed to him to be premature at present to express any opinion upon the value of the gas produced. The whole affair was in very good hands; Mr. Spice had experience and talent, and was a man of perfect integrity, and, therefore, they might rely on it they would ultimately know the true value of the invention, both in its engineering and its commercial aspect. For his own part he (Mr. Stevenson) left it in Mr. Spice's hands with the most entire confidence. Probably this time next year he would be able to tell them something more about it.

Mr. G. Anderson asked whether the 1s. 8d. given as the cost per 1000 cubic feet included wear and tear and the ordinary expenses into the gasholder.

Mr. Spice said the 132,000 cubic feet did not apply to the £16. The 132,000 cubic feet of heating gas became 165,000 cubic feet of lighting gas by being passed through the petroleum spirit, and the cost was a fraction below 1s. 8d. per 1000, all charges included, into the gasholder, the increase in volume being 25 per cent.

Mr. R. H. Jones (Dover) read the following paper on

GASHOLDER CAPACITY COMPARED WITH CONSUMPTION.

What should be the gasholder storeage in a well-managed gas-work?

I think this question is one which may be discussed by gas managers, and with very much advantage to those who are short of gasholder storeage, and who find it difficult to persuade their directors to provide for the increasing wants of their business.

This question also commends itself to the attention of such of the members of this association as are desirous of promoting the movement for the reduction of Sunday labour in gas-works, for with an insufficient storeage for gas it is impossible to reduce the labour on Sundays.

As I am a man of figures, I thought the collation of statistics from different gas-works in the kingdom would give one some idea of what is generally considered as a sufficient per centage of gasholder storeage as compared with the maximum daily consumption, and I accordingly sent out some 350 circulars to managers of gas-works, and have received answers to about one-half of my circulars.

These replies I have grouped under five different heads—viz.,

Group A.—Returns from small gas-works where the maximum daily consumption is below 100,000 cubic feet.

Group B.—Where the maximum daily consumption is between 100,000 and 250,000.

Group C.—Where the maximum daily consumption is between 250,000 and 500,000.

Group D.—Where the maximum daily consumption is between 500,000 and 1 million.

Group E.—Where the maximum daily consumption exceeds 1 million.

It will be seen from these returns that the gasholder capacity in one case is as low as 32 per cent., and in another it is as high as 200 per cent.; but on striking an average,

Group A., with 53 gas-works, gives a per centage of gasholder room, as compared with the maximum daily consumption, of	91·8	per cent.
Group B.—42 gas-works, average	105	,,
Group C.—26 ,, ,,	89·8	,,
Group D.—15 ,, ,,	87·2	,,
Group E.—17 ,, ,,	88·3	,,
General average of the 153 gas-works	89¾	,,

It will be seen from these returns that in many cases additional gasholder storeage is much needed. On referring to the returns, I find many observations are added, thus:

The manager of a gas-work, with only 44 per cent. of gasholder storeage, writes: "Our vend is very much restricted by want of gasholder room; the difficulty of maintaining the supply during a winter's evening is the occasion of great and unceasing anxiety, and our stocks within the season referred to usually range from 5 to 20 minutes consumption."

Another manager, with 46 per cent. of gasholder, writes: "Ours is a very rare case; we have to keep extra retorts alight to meet the supply."

The manager of a gas-work, with 65 per cent. of gasholders, writes: "We want more gasholder capacity badly, but wish to avoid putting up a new holder, and so increasing our capital while coal is so dear."

Another manager, with 63 per cent. of gasholder, writes: "You will see our gasholder capacity is miserably deficient. We are just going in for a large extension."

Several of those gas-works, where the storeage is less than 70 per cent., are about enlarging their gasholder capacity, and nearly all complain of insufficient storeage.

One gentleman, with 86 per cent., complains of being "short of gasholder capacity."

Another gentleman, a valued member of this association, and one of its vice-presidents, writes: "That his gasholder storeage has been recently increased to 98 per cent. of the maximum daily make," and adds, "this is not at all too much."

Opinions differ. I think myself that 98 per cent. is "not at all too much." The statistics I have collated show an average of 89¾ per cent.; but I have seen the written opinion of another eminent member of the gas profession, advising a board of directors that, with gasholders holding two-thirds (66 per cent.) of the maximum daily consumption, no extra retorts are required, and that consequently 66 per cent. of storeage is sufficient.

The object of my asking to be allowed to lay this paper before the members of the association of gas managers is to solicit their opinions as to what gasholder storeage should be provided to carry on the manufacture and supply of gas with safety and economy, and what additional storeage is needed to meet the movement for the diminution of Sunday labour.

Of course, in some localities, there is a large consumption of gas during daylight, and in the northern parts of the kingdom there is not so much daylight in winter time as in the south. These specialities require to be noticed in the discussion which may ensue on reading this paper.

GROUP A.

Fifty-Three Gas-Works—Maximum Daily Consumption below 100,000 *Cubic Feet.*

Maximum Consumption.	Gasholder Capacity.	Per Centage.
80,000	30,000	37
64,000	28,000	43
78,000	36,000	46
27,000	14,000	52
57,000	32,000	56
70,000	40,000	57
55,000	32,000	58
36,000	21,000	58
60,000	35,000	58
61,000	40,000	65
60,000	40,000	66
48,000	32,000	66
26,000	18,000	69
90,000	63,000	70
27,000	19,000	71
38,000	28,000	73
90,000	70,000	77
14,000	11,000	78
45,000	36,000	80
50,000	40,000	80
40,000	34,000	85
70,000	60,000	86
75,000	65,000	86
75,000	66,000	88
95,000	85,000	89
86,000	77,000	89
80,000	73,000	91
71,000	68,000	95
27,000	26,000	96
76,000	75,000	98
76,000	75,000	98
46,000	46,000	100
11,000	11,000	100
20,000	20,000	100
54,000	54,000	100
56,000	56,000	100
45,000	46,000	102
87,000	90,000	103
28,000	29,000	103
90,000	95,000	105
60,000	65,000	108
55,000	62,000	112
14,000	16,000	114
50,000	62,000	124
2,463,000	2,021,000	

Maximum Consumption.	Gasholder Capacity.	Per Centage.
2,463,000	2,021,000	
80,000	100,000	125
11,000	14,000	127
53,000	68,000	127
60,000	80,000	133
35,000	50,000	143
50,000	76,000	152
9,000	14,000	155
80,000	130,000	162
72,000	122,000	169
2,913,000	)2,675,000	(91·8 per cent. of gasholder storeage compared with maximum daily consumption.

GROUP B.

Forty-Two Gas-Works—Maximum Daily Consumption 100,000, *and under* 250,000 *Cubic Feet.*

Maximum Consumption.	Gasholder Capacity.	Per Centage.
102,000	54,000	52
175,000	100,000	57
168,000	98,000	58
234,000	140,000	60
100,000	60,000	60
185,000	116,000	62
174,000	110,000	63
150,000	100,000	66
120,000	90,000	75
130,000	98,000	75
248,000	200,000	80
148,000	120,000	81
110,000	90,000	81
120,000	100,000	83
110,000	92,000	83
130,000	110,000	84
155,000	134,000	86
160,000	140,000	87
200,000	190,000	95
105,000	110,000	96
168,000	156,000	98
230,000	225,000	98
190,000	190,000	100
170,000	192,000	113
149,000	178,000	120
207,000	250,000	120
146,000	180,000	123
180,000	240,000	125
136,000	170,000	125
230,000	290,000	126
195,000	250,000	128
115,000	154,000	134
110,000	150,000	135
147,000	200,000	136
130,000	178,000	137
180,000	260,000	144
100,000	146,000	146
120,000	180,000	150
160,000	246,000	153
210,000	346,000	165
100,000	180,000	180
110,000	220,000	200
6,507,000	)6,833,000	(105 per cent. of gasholder storeage compared with maximum daily consumption.

Group C.

Twenty-Six Gas-Works—Maximum Daily Consumption, 250,000 *to* 500,000 *Cubic Feet.*

Maximum Consumption.	Gasholder Capacity.	Per Centage.
410,000	130,000	32
400,000	210,000	52
300,000	163,000	54
380,000	212,000	55
260,000	150,000	57
290,000	190,000	65
300,000	210,000	70
260,000	220,000	71
454,000	330,000	72
290,000	220,000	76
250,000	200,000	80
400,000	320,000	80
400,000	324,000	81
480,000	390,000	81
452,000	400,000	88
330,000	295,000	89
363,000	335,000	92
270,000	250,000	92
448,000	461,000	103
280,000	295,000	105
270,000	290,000	107
450,000	520,000	115
330,000	400,000	121
496,000	600,000	121
480,000	700,000	146
440,000	700,000	159
9,483,000	)8,515,000(	89·8 per cent. of gasholder storeage compared with maximum daily consumption.

Group D.

Fifteen Gas-Works—Maximum Daily Consumption, 500,000 *and under* 1,000,000 *Cubic Feet.*

Maximum Consumption.	Gasholder Capacity.	Per Centage.
701,000	325,000	46
580,000	300,000	52
580,000	345,000	60
520,000	312,000	60
500,000	305,000	61
575,000	400,000	69
500,000	400,000	80
500,000	400,000	80
755,000	650,000	86
860,000	750,000	87
512,000	485,000	94
720,000	700,000	97
850,000	1,040,000	122
800,000	1,000,000	125
720,000	1,020,000	141
9,673,000	)8,432,000(	87·2 per cent. of gasholder storeage compared with maximum daily consumption.

GROUP E.

Seventeen Gas-Works—Maximum Daily Consumption, 1,000,000 *Cubic Feet and upwards.*

Maximum Consumption.	Gasholder Capacity.	Per Centage.
1,260,000	750,000	60
1,170,000	722,000	61
1,200,000	820,000	68
6,187,000	4,274,000	69
2,200,000	1,600,000	72
1,200,000	900,000	75
16,000,000	13,000,000	81
2,750,000	2,300,000	83
1,400,000	1,171,000	83
2,370,000	2,250,000	95
3,666,000	3,630,000	98
5,300,000	5,300,000	100
2,004,000	2,140,000	106
3,500,000	3,800,000	108
1,250,000	1,500,000	116
1,500,000	1,800,000	120
1,721,000	2,329,000	135
54,678,000	)48,286,000(	88·3 per cent. of gasholder storesge compared with maximum daily consumption.

Averages.

	Maximum Consumption.	Gasholder Capacity.	
Group A	2,913,000	2,675,000	
„ B	6,507,000	6,833,000	
„ C	9,483,000	8,515,000	
„ D	9,673,000	8,432,000	
„ E	54,678,000	48,286,000	
Total	83,254,000	) 74,741,000 (	89·77 per cent. of gasholder storeage compared with maximum daily consumption.

Mr. CRAVEN (Batley) thought the gasholder capacity should be equal to one maximum day's consumption, as a rule.

Mr. HUNTER (Rochdale) said there was a fallacy in the arguments used by gas managers who wished to shirk the question of abolishing Sunday labour in gas-works. He *understood* Mr. Jones to say that in many gas-works Sunday labour could not be avoided on account of the deficiency in storeage capacity, and numbers more argued in the same way. This must be fallacious, because it followed that if the storeage were only 50,000, and the consumption 100,000 six days in the week, it was the latter that ruled the number of retorts required to be in use; and it followed that if the consumption six days in the week was 100,000 each day, on the Sunday it would be so much less. At any rate that was the rule; consequently, instead of short storeage being an excuse for not avoiding Sunday labour, it was the very thing that compelled a manager to reduce it. And it sounded reasonable when he said that by keeping on the maximum number of retorts compared to the consumption, or the slightest excess, and by working to six on Sunday morning and from six on Sunday night, a manager, under the circumstances described, by Monday night would find as much gas made as he could possibly store. No doubt, on the other hand, a gas manager with an excess of storeage could work with a reduced number of retorts, and by working on the Sunday could make up the loss of the week. But such a course would be wrong, as it would certainly be doing on the Sunday what could and ought to be done on the week day. However, he only named this to show the fallacy of the argument when a manager stated that he could not avoid Sunday labour on account of deficiency in storeage. In regard to

storeage compared to consumption, last winter the maximum consumption in Rochdale was about 1½ million cubic feet in the 24 hours, and the storeage 600,000 only. He did not envy any one working under such difficulties. Past experience led him to the conclusion that under ordinary circumstances the minimum storeage capacity ought to be equal to 75 per cent. of the maximum consumption in the 24 hours. Under any circumstances provision ought to be made in the retort-house, purifiers, gasholders, and throughout the works, so that all operations on a gas-work could be suspended for at least 12 hours on the Sunday. It could be done; and having settled the possibility, whether it was more expensive or cheaper, it ought to be done. Physically, intellectually, and morally the men required it, and the laws of God demanded it.

Mr. WOOD (Bury) said the question of gasholder capacity must be determined a great deal by the varying circumstances of the consumption in each locality. A town where private residences predominated could not be compared with a town full of manufactories. No arbitrary rate of per centage could be laid down, but the relative consumption of each town or district must be taken into consideration. In his own town the increased consumption by the mills from five to six o'clock in the evening was double what it was from six to seven o'clock.

A vote of thanks having been given to Mr. Jones, the proceedings in relation to the reading of papers were closed.

The reading of these papers, and the discussions thereon, having occupied the whole of the time available for this part of the proceedings, the following communications were necessarily omitted to be read, but by the kind permission of the writers they appear as an appendix to this report:—

"Standard Gas-Burners," by Mr. W. Sugg, London.

"A New Compensator and Bye-Pass," by Mr. D. Laidlaw, Glasgow.

"Construction and Choice of Materials for Gas Apparatus," by Mr. R. Dempster, Elland.

"On the Method of Calculating Flow of Gas through Pipes," by Mr. J. Paterson, Warrington.

ELECTION OF OFFICERS.

The scrutineers reported the result of their examination of the ballot papers, from which it appeared that the following gentlemen had been elected as officers, &c., for the ensuing year:—

President.—G. T. Livesey, Esq.

Vice-Presidents.—Messrs. James Paterson, Joseph Wood, and Thomas N. Kirkham.

Treasurer.—H. Newall, Esq.

Committee (new members to replace those going off by rotation).—Messrs. A. Cockey, C. Craven, and H. Bowen.

Auditors.—Messrs. S. P. Leather and A. Hersee.

Secretary.—Mr. W. H. Bennett.

TIME AND PLACE OF NEXT MEETING.

It was resolved that the next annual meeting be held in London on the second Tuesday in June, 1874.

REPORT OF THE COMMITTEE ON THE ESTABLISHMENT OF A PROVIDENT FUND, PROPOSED AMALGAMATION WITH THE NORTH BRITISH ASSOCIATION, &c., &c.

Mr. WOOD, of Bury, in the absence of the secretary from temporary indisposition, read the following report:—

Gentlemen,—In accordance with the resolution passed at the last annual general meeting in reference to the establishment of a benevolent fund, and deputing the committee to consider the arrangement and disposal of such fund if one were formed, your committee beg to report that a circular was sent out to each member for the purpose of ascertaining how many subscribers there would be, and the probable amount of income that might be depended upon. The responses to these inquiries are in the opinion of your committee insufficient to justify the recommendation of the establishment of such a fund.

The president, however, is most anxious to promote the interests of the association, and has, therefore, desired the acceptance of the £100 which he pro-

posed to contribute to the benevolent fund, to be invested for the benefit of the association in such manner as a committee, consisting of himself, Mr. Church, and Mr. Goddard, shall think fit, and that the interest arising therefrom be devoted to the award of a special premium for meritorious papers read before the association.

In consequence of the increasing income of the society, the committee recommend that a special committee, consisting of three members resident in London, be elected to act as a Finance Committee, with instructions to open a banking account in the name of the association; and, in future, all payments be made by cheques signed by two members of such committee, and countersigned by the secretary.

The committee therefore propose—"That the Messrs. Thomas Livesey, J. Church, and G. W. Stevenson be and they are hereby elected as a Finance Committee for the ensuing year, and that such Finance Committee meet periodically, and be *ex officio* members of the general committee during their term of office."

It was unanimously resolved, at a committee meeting held on the 22nd of April last—"That in consideration of the valuable services rendered to this association by Mr. William Sugg and Mr. F. W. Hartley, those gentlemen be recommended for election as honorary members."

At a meeting of the committee, held on the 22nd of April last, the propriety of establishing an office in London for the use of the association was suggested, and as Mr. Bennett had a room which could be placed at their disposal, it was unanimously resolved—"That a provisional arrangement be entered into with Mr. Bennett for the use of one of his rooms for the purposes of the association, at a rent of not more than £40 per year."

It was also unanimously resolved at the same meeting—"That the association be recommended to appoint Mr. W. H. Bennett as their secretary, at a salary of £100 per annum."

It is also proposed by your committee, in consideration of the high scientific attainments of Dr. Stevenson Macadam, and his kindness in consenting to deliver to the association the valuable lecture of yesterday evening, that he be elected an honorary member of this association.

The President: I have now to lay before the meeting a resolution which has this day been adopted at the meeting of the North British Association of Gas Managers. It is as follows:—"That while this association desires to maintain friendly relations with the British Association of Gas Managers, by having combined meetings as frequently as possible, and in other ways to promote the interests of both societies, resolved that in the meantime the North British Association retain its independent position, and take charge of its funds and all matters necessary to its continuance." You will please take this as a part of the report of your own committee, and I shall put it to the meeting that you approve of the report in its entirety. I may tell you that the committee have fully and repeatedly discussed every point mentioned in the report, and in presenting it to you I can give you the assurance that every suggestion has met with their unanimous and unqualified approval. I therefore have much pleasure in moving the adoption of the report.

Mr. G. Anderson seconded the motion, which was unanimously agreed to.

Thanks to the Secretary.

The President: Gentlemen, the next business has reference to our secretary. I think that a gentleman who has devoted so much time and talent as Mr. Bennett has done to the interests of this association deserves a special acknowledgement of his services. I propose, therefore, that in his absence we give him a hearty vote of thanks.

The resolution was put, and carried unanimously.

Proposal to Print Papers before Meeting.

Mr. Douglas suggested that it would be advisable, in making arrangements for the future meetings of the association, that the whole of the papers to be read should be printed, and copies sent to the members some time previously, so that they might come better prepared to discuss them than they could possibly do after hearing them read at the meetings.

The President said he thought it would be impossible to carry out such a plan, as, notwithstanding every exertion on the part of the committee and the

secretary, many of the papers were not delivered by the writers till shortly before the meeting.

Mr. BROADHEAD corroborated the remarks of the president, and quaintly remarked that he feared, if the papers were circulated before the meeting, some of the members would stay at home and read them quietly by themselves, instead of joining their brethren for discussion and the interchange of thoughts upon them.

Mr. METHVEN doubted whether there need be any difficulty in the matter. The committee could as readily obtain the papers two months before the meeting as one week, if they would only limit the time for receiving them. He took the opportunity also of remarking that when members had gone to the trouble of preparing papers, they would scarcely be satisfied if they were left out in the cold, and no discussion took place upon them.

The PRESIDENT announced that he had received a letter from the manager of Young's Paraffin Light and Mineral Oil Company, conveying an invitation from the directors of that company to the members of the association to inspect the various processes carried on at their works in the manufacture of paraffin oil.

NEW HONORARY MEMBERS.

Mr. HARTLEY: Gentlemen, I simply ask permission to return my thanks for the honour you have just conferred upon me by electing me an honorary member of this association. I cannot, in the few words I feel at liberty to detain you with, express the gratification which your kindness has awakened in my breast. I will only say, I fully appreciate the compliment paid to me, and offer you my sincere thanks.

Mr. SUGG: Gentlemen, permit me also to express my thanks for the great honour done to me. I can assure you that, as in the past so in the future, I shall endeavour by every means in my power to forward the interests of the association.

VOTE OF THANKS TO THE PRESIDENT.

Mr. GODDARD: I am sure, gentlemen, we cannot allow this session to terminate without expressing our thanks to Mr. Croll for the very able manner in which he has presided over the business of the meetings. I have, therefore, great pleasure in proposing—"That the thanks of this meeting be presented to A. Angus Croll, Esq., for the very able manner in which he has conducted the business of this session."

Mr. JABEZ CHURCH: I have great pleasure in seconding a proposition which, I am sure, will be received by the meeting in the most cordial manner.

The motion was put, and carried by acclamation.

The PRESIDENT: Gentlemen, I can only say that I fully appreciate your kindness, and that I thank you very much for the vote you have just passed. It has been a great pleasure to me to preside over your deliberations, and I feel grateful to every member of the association for the great attention and consideration shown towards me while occupying the high position to which you elected me. I shall ever remember your kindness and the great courtesy exhibited to me, and I shall continue to cherish, as I have hitherto done, a warm interest in the affairs of the association.

The business sittings were thus brought to a close.

During the meetings of the association, a number of drawings and models were exhibited in the hall, which excited a considerable amount of interest. Among these we may mention—

Drawings of apparatus for the purification of gas from ammonia, sulphur, and carbonic acid, by Mr. George Anderson.

Drawings of combined self-acting bye-pass and compensator, by Messrs. Laidlaw.

Drawings of exhauster-house, showing position of connexions, exhauster, and bye-pass valve for Salford Corporation Gas-Works, by Messrs. Laidlaw.

Drawings of exhauster and engines for Salford Corporation Gas-Works, by Messrs. Laidlaw.

Model of patent self-acting hydraulic safety-valve for preventing the back flow of gas from gasholders, by Messrs. Thomas and Caffall.

Model of Best and Holden's apparatus for drawing and charging retorts, by the Steam Stoker Company.

Model of self-acting lighting and extinguishing apparatus, the invention of Mr. A. F. Wilson.

Model of Somerville and Robinson's apparatus for drawing and charging retorts, by the Steam Stoker Company.

Drawings of breeze and tar fuel machines, with specimens of breeze and tar made into fuel therewith, by Mr. G. Anderson.

Banquet in the Masonic Hall.

On the evening of Wednesday, a grand banquet was given by their Scottish friends to the members of the British and North British Associations, in the magnificent hall of the Freemasons, George Street. The company, which numbered nearly 350 gentlemen, were seated at four tables at right angles to the raised platform at which were the chairman and his supporters, and extending the whole length of the rooms. These tables were tastefully ornamented with plants and flowers. William Fraser, Esq., of Inverkeithing, occupied the chair; and A. Donaldson, Esq., of Edinburgh, officiated as croupier. The chairman was supported on his right by Edward Goddard, Esq., Mayor of Ipswich; Jabez Church, Esq.; Bailie Cousin, Dr. Stevenson Macadam, G. Harrison, Esq.; Major Laidlaw, H. Bartholomew, Glasgow; and on his left by Bailie Howden; Messrs. J. K. Watson, Edinburgh Gas Company; J. Reid, Edinburgh and Leith Gas Company; J. Milne, Edinburgh; W. H. Bennett, secretary; George Garnett, Ryde; Samuel Stewart, Greenock; R. P. Spice, London. The croupier was supported by ex-Councillors Romans, Henry Alder, James M'Kelvie, Edinburgh; D. M. Mackay, engineer; Alexander Mackay, meter manufacturer; William Brown, Manchester; and Mr. Burgess, Huddersfield.

The banquet was served in most excellent style by Messrs. Hunter and Glover, St. Andrew's Square, and ample justice was done to it by the assembled guests.

After dinner, the Chairman gave the toast of "The Queen," which was enthusiastically received, the company singing the National Anthem. The next toast, "The Prince and Princess of Wales, and the other Members of the Royal Family," was equally honoured, the company singing, in full chorus, "God Bless the Prince of Wales."

The Chairman next gave "The Navy, Army, and Reserve Forces," which was cordially received, and was briefly acknowledged by Major Laidlaw.

The Croupier, in appropriate terms, gave "The Lord Provost and Magistrates," and he read apologies for unavoidable absence from the Lord Provost and other members of the Edinburgh Town Council.

The toast was heartily responded to.

Bailie Howden, in reply, said he had been called upon more than once to respond to a similar compliment, perhaps not in a meeting so largely attended, but he had never been called upon till then to acknowledge the compliment from a body of gentlemen possessed of such high culture and such distinguished scientific acquirements as were met there that evening. He concluded by regretting that no time had been given the town to welcome the associations as befitted Edinburgh, but he was sure the citizens would be delighted to see them back again. If the magistrates had been informed in time of the arrival of such a distinguished body they would have taken some means of manifesting their approbation of their visit, and shown them more kindness and hospitality than they had been able to do.

The Chairman then said he rose with some diffidence and with much feeling to propose what might be called the toast of the evening. He wished that some abler man, and one occupying a higher position than himself, had had an opportunity of doing it rather than he, but, at the same time, he was willing to do the best he could, and he was very much encouraged to proceed with the toast, because he felt that it was one which required not the flowers of eloquence. When the British Association of Gas Managers resolved last year that it should meet in Edinburgh this season, he, along with two or three friends who were there as extra-ordinary members, immediately determined in their minds to make the meeting in Edinburgh more than usually successful and attractive—to make it as auspicious as any that had gone before of this excellent and worthy institution. On their returning to Edinburgh, they found that their friends here were inflamed with same desire. The feeling which animated all of them was this—that as in the course of business they had occasion to visit England and Ireland, and there received kindness from one and all, they

should certainly do something to honour them on this occasion. When in England, they had formed friendships which they had found to be as warm and true as any they had had the pleasure of forming. He had been a member of the British Association for four years, and at every meeting since that time he had attended with great comfort and pleasure. He always looked forward to the annual meeting, as from the instruction there given he reaped great advantages.

The toast was drunk with great cordiality.

Mr. JABEZ CHURCH, ex-president, said he was unexpectedly called upon to respond to the toast, owing to the indisposition of their worthy president, Mr. Croll. The Association of Gas Managers had been established ten years ago, and the child which was born at that time had grown and prospered until it now presented a most healthful and robust appearance. That was a source of congratulation to them all. The association had been formed to enable them to have a social interchange of thought on matters pertaining to their profession, and to afford an opportunity to the younger members to profit by the wisdom and experience of their elders; and what the juniors learned in this manner they ought to acknowledge with gratitude, and appreciate as of the greatest value. He thought the association had done good, not only to its own members, but to the public generally. According to his own experience he thought the interests of gas managers were identical with those of the shareholders and consumers. If they were not, they were placed in a false position. Assuming it to be the fact, however, it behoved them to determine the best means of producing an article which was now of the greatest possible importance both commercially and socially. Without being egotistical, they should look upon themselves as the lights of the present day. He thought there ought to be a spirit of emulation amongst them, that they should not be satisfied with the present means of lighting, and he was of opinion that hereafter there would be great improvements made in the manufacture of gas, and a reduction in the cost of its production. They should embrace all inventions of a practical nature which would assist in the development of such improvements, because in doing so it would be to their interest individually as well as collectively. In coming to Edinburgh, he was sure all the members of the British Association were gratified and delighted with the reception their Scotch brethren had given them. They had had great expectations, but these had been perfectly overwhelmed—they had no proper idea of the magnificent manner they were to be entertained in Scotland. It was, he could assure them, the best the association had ever met with in their history; and while cordially thanking the Scotch brethren, he expressed the hope that they would be privileged to meet with them again in Edinburgh.

The CHAIRMAN next proposed the "North British Association of Gas Managers." In doing so he referred to the proposed amalgamation of the two societies. It had been resolved, he said, at all events by the Scotch association, not to go on at present with that union. One of the considerations which had influenced a number of the members was this, that if they were obliged to follow the united association through the country—say at Leeds one year, and Southampton another—they would find it very difficult to attend. They all acknowledged that they received great benefit from the Scotch institution, and most of them attended the meetings with great regularity. The papers read at their meetings were of such a high character that he believed they would stand alongside any read at the sister society. The Scotch association was now 14 years old, and he believed was the pioneer to some extent of the British Association. He trusted the society would go on as prosperously as ever, and be the means of doing much good to the members composing it. There was no feeling of jealousy or rivalry existing between the two associations, and this he was sure their English friends would abundantly prove by drinking the toast with all the honours.

Mr. J. K. WATSON, of Edinburgh, a past president of the North British Association, in replying to the toast, said that no one would regret the desire to continue the association as a separate institution, but at the same time he thought it was almost a pity that the union had not been effected.

The remaining toasts were—"The Secretaries," given by Mr. D. Bruce Peebles, and responded to by Mr. Bennett; "The Directors of the Gaslight Companies of Great Britain and Ireland," by ex-Councillor Romans; "Dr. Stevenson Macadam," by Mr. John Reid, Leith; "The Commercial and In-

dustrial Interests of Scotland," by Mr. E. Goddard, Mayor of Ipswich, and responded to by Mr. George Harrison; "The Press," by Mr. Paterson, Warrington, replied to by Mr. W. B. King, of the JOURNAL OF GAS LIGHTING; "The Chairman;" "The Croupier," by Mr. Jones, Dover; and "The Stewards," by Mr. Macnie, Londonderry.

The proceedings, which were enlivened with several songs, were of an enthusiastic description, and the company broke up at a late hour.

THURSDAY, JUNE 12.

The proceedings in connexion with the joint meetings of the associations were concluded this day by the excursion which had been arranged by the Scotch friends.

A special train at 8.40 a.m. from the Waverley station conveyed the company, which numbered nearly 320, including many ladies, *viâ* Falkirk, to Cowlairs, and thence to Helensburgh, the pace being slackened as the train passed the extensive new gas-works now being erected by the Corporation of Glasgow at their Dawsholm station, where, had time allowed, advantage would have been taken of the permission given by Mr. Foulis, the engineer, to make an inspection. Arriving at Helensburgh shortly after eleven o'clock, the company were met at the station and welcomed by a large number of friends, and also by a couple of pipers in full Highland costume. Preceded by the pipers, the party went from the station to the steamer *Chancellor* at the end of the pier, a number of Scottish airs being played along the route. The steamer crossed the Clyde to Greenock, and thence proceeded up Loch Long. A heavy rain set in, and unfortunately continued to prevail until within a few minutes of the arrival at Arrochar, so that much of the magnificent scenery through which they passed was lost to all but a few hardy souls who were prepared to brave the elements on deck. At Arrochar the party disembarked, the gentlemen walking across the moorland to Tarbet, and the ladies being conveyed in vehicles which were in waiting. On the arrival at Tarbet, photographic groups of the party were taken on the green in front of the hotel.* This permanent memorial of their bodily presence in the Highlands having been completed, the company, with sharpened appetites, embarked on board the splendid steamer *Prince Consort*, which lay off Tarbet on Loch Lomond directly opposite Ben Lomond, and here an excellent dinner was served under the purveyorship of the steward, Mr. William Lang. A short sail up the lake was then made towards Inversnaid, that the visitors might catch a glimpse of some of the finest scenery of this romantic district, for which the clearing up of the weather gave a full opportunity. The steamer then proceeded southward, landing the passengers at Balloch, whence they were conveyed by train to Edinburgh. On arriving at the Waverley station, the company assembled in a group on the platform, and

Mr. JABEZ CHURCH was called upon to address them. He said: Mr. Fraser, Mr. Donaldson, and gentlemen of the Entertainment Committee, I have been requested by the guests whom you have so generously entertained to express to you before we finally part the high sense we cherish of your lavish kindness, and of the pleasure we have derived during our visit to your city. You have this day given us an additional proof of your kind and fraternal feeling, and of your unbounded hospitality. You have not only studied our creature comforts in a manner which we all most heartily appreciate, but you have given us food for our souls. You have taken us to see some of the beauties of your romantic country, and the scenes we have had the privilege to visit to day will dwell as pleasant memories with us during life. We cannot part without offering to you the assurance of our heartfelt gratitude, and of our entire satisfaction with the arrangements made by you for our comfort and enjoyment.

Mr. GODDARD, in seconding the vote, said: Gentlemen, I was requested to say a word or two in acknowledgment of your great kindness to us as an association, but my friend Mr. Church has so completely embodied our feelings in the few remarks he has made that it is unnecessary I should make any observations. You have entertained us most sumptuously; we have had "the feast

* Copies of these photographs may be obtained from Mr. John Stuart, photographer, 120, Buchanan Street, Glasgow.

of reason and the flow of soul;" we have had the privilege to meet face to face with gentlemen with whom we have corresponded for years, but whom we never saw before, and I am sure that friendships have been formed since we have been in Edinburgh which will be cherished as long as we live. We leave your modern Athens at the call of duty, with feelings of regret, but we carry with us the remembrance of your hospitable reception, and offer to you our most sincere and hearty thanks for the same.

The resolution was carried amidst loud cheers.

Mr. ROMANS responded, expressing on behalf of the Scotch friends their great delight at the pleasure they had been able to furnish to the members of the two associations. It was most gratifying to find that no sooner was the proposal made to give a friendly reception to the visitors than it was entered into with the utmost cordiality, and in the most liberal spirit. All the necessary arrangements to carry out their desires had worked most smoothly and pleasantly, and it would be to the subscribers, as well as to the Entertainment Committee, a very pleasant thing to receive the vote just carried as the expression of the satisfaction of the members of the association with the efforts made to render their visit to the metropolis of the North an agreeable one.

Mr. DONALDSON also acknowledged the vote, and proposed three cheers for the ladies who had accompanied the members on the excursion.

The invitation was very heartily responded to, and the whole company having joined in singing "God Save the Queen," the proceedings connected with the anniversaries of the associations were brought to a close.

APPENDIX.

The following papers presented at the Meeting of the Association were, for want of time, taken as read, and were ordered to be entered on the "Transactions":—

STANDARD GAS-BURNERS.

By William Sugg, A.I.C.E.

My first studies with respect to "standard burners" commenced in 1858, when, observing the difference, not at all slight, in the evidence given by some of the most eminent scientific men of the day relative to the illuminating power of what was supposed to be the self-same gas, I had the temerity to doubt, not the witnesses, but the photometrical apparatus with which they performed their experiments. A careful examination of the question and a lot of so-called standard burners, which I obtained from different gas-works, very soon enabled me to see that all the difference in this scientific evidence might be easily accounted for without going any further than the burners. When I tell you that there was a difference of nearly six candles in as many of these infallible burners, I think you will agree with me that it is a wonder the scientific evidence was so nearly alike, and that instead of 25 per cent. difference in their estimation of 12-candle gas, there might as easily have been 50 per cent. Having so wide a field, I could not very well fail to do something better, and so I produced in 1858 the 12-candle Sugg's standard burner. Here is a drawing of it in section and plan.

You will perceive it is simply an ordinary Argand long-chamber burner, with the iron top taken out and a steatite top put in. I was led to adopt the steatite, finding it was a very hard material, which could not be altered (it is harder than the hardest steel), and, as far as I could find, not affected by the action of heat or damp.

The old iron tops I found could never be kept long to any definite gauge, in consequence of oxidation.

The drawing is to a scale, and you will perceive that the area of the centre opening is more contracted than was usual with burners made at that epoch.

This burner was first used by the late Mr. Henry Banister, at the Chartered Westminster station, and was shown by the late Mr. George Lowe to a committee of the House of Commons, to whom he recommended that it should be adopted as a standard burner.

This was the first time that this proposition that the testing-burners should be made upon the same model was introduced to the notice of Parliament. Attention having been drawn to the important *resuscitated* fact that 5 cubic feet of gas could be made to evolve a very different power of light, according to the conformation of the burners through which it was consumed, almost all of the parties interested agreed at once that it was highly desirable that a model burner should be adopted. At this distance of time it doubtless appears to you that so self-evident a proposition ought not to require an hour's discussion, and that nothing could be easier than to determine upon a burner, and decide that in future all standard burners should be made upon that model, uniformity being, of course, the only thing required.

Perhaps before I have done I shall show you that this very easy-going, plausible-looking axiom—well enough as applied to some things—will not do in the sense in which it is generally used as regards standard burners. Certainly, nothing can be truer than that uniformity in the form of standard burners is very desirable, but that is very far from being the only thing required; comparatively it is but an inferior part of the question.

PER ON GAS BURNERS.

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UGG'S

dle Burner.

Dublin Burner.

Cannel Burner.

Whiteman & Bacs, *Litho to the Queen*

UNIV. OF MICH.

The first, and, perhaps, most important, point raised by the adverse parties at the time of the introduction of this burner by Mr. George Lowe was this—Shall that burner be adopted which gives the highest photometrical result, or *vice versâ?* Examined by the light we now possess on the subject, the question is a manifest absurdity. We say gas can only be of that illuminating power represented by the quantity of carbon and hydrogen it contains per cubic foot. Thus simply the standard quantity of 5 cubic feet contains, roughly speaking, so many grains of carbon in various forms diffused through a certain quantity of hydrogen and a little sulphur. These, brought into contact with the proper equivalent of oxygen necessary for their combustion, will evolve a certain amount of light which can under no circumstance be increased, although it may be diminished, either wilfully or accidentally.

If, therefore, by improperly consuming it, we only obtain 10 candles out of a gas which is capable, if properly consumed, of evolving as much light as can be got out of 14 sperm candles of six to the pound, when burning at the rate of 120 grains per hour, can it be said by any reasonable being that the gas in question is not 14-candle gas?

However you may answer this question, the opponents of the gas companies, with the late Mr. Samuel Hughes at their head, resolved that they would accept no model burner of any kind, considering it would be to their interest to leave the question open, and themselves free to make use of any burner they chose; so Mr. Lowe and his burners, not being sufficiently supported, were thrust out of the committee-room. Permit me to say, in parenthesis, that you will see, as I go on, that two principles which have exerted a considerable effect upon all mundane creations have very much affected standard burners. These principles are destruction and development. Unfortunately for gas, the former principle has had, up to the present, most decidedly the best of the battle; and, like an evil genius, has constantly interfered to introduce discord and confusion whenever there has been a chance. The principle of destruction has been and is now extensively at work in burners for consumers use. The rule is, if the gas is *smoky*, to bring down or destroy the illuminating power by a large admixture of air till it is on a level with *clean* gas. This is, of course, more easily done than to develop the illuminating power existing in the *smoky* gas, and then, besides, there is a *great economy* in burners. In consequence of the rejection of Mr. Lowe's proposal, for some time after this, adverse testers described the same quality of gas in very different terms. The testers for the companies stated the value of the gas as 14 or 15 candles, and the official tester for the different public bodies (consumers) stated its value variously from 11 to 12, and even lower. Mr. Hughes himself, on one occasion, triumphantly proved to his own satisfaction and that of the party for whom he was engaged that the gas supplied by one of the London companies and several of the provincial ones—notably Hanley, Potteries—was no more than 8 candles. Nevertheless, in the latter part of 1861, or beginning of 1862, Dr. Letheby, who was, I believe, the first official tester to see the matter in the proper light, substituted a modification of the Sugg's 12-candle burner for the old iron-top burner he was using at Jewry Street testing-station. After some discussions, the Corporation of London accepted it, and for many years, until the appointment of the gas referees under the Metropolis Gas Act, it was the acknowledged standard burner.

This burner for 14-candle gas was the first parliamentary standard burner. It is very much like the 12-candle burner shown in the diagram, differing in the size of the centre opening, which is ·48 instead of ·44 of an inch, and in having a perforated disc placed at the bottom of the gallery for the purpose of equalizing the admission of air.

About that time the Birmingham and Staffordshire Gas Company came before Parliament, and their bill was seized upon as a kind of battle-ground upon which to fight out the rival theories of destruction and development. The company desired to have leave to supply 14-candle gas at a certain price agreed upon between the company and their opponents. Everything also, as I believe, having been settled, the *only* question in dispute between them was the kind of burner by which to measure the illuminating power of this 14-candle gas. Mr. Hughes and his party, in opposition to the company, instructed, as they now were, that the pecuniary value of the gas could be very much influenced by the kind of burner they employed, desired perhaps, having made their contract, to

obtain a better article than that they had bargained for, and instead of adopting the straightforward course of fighting the question of price upon its commercial merits, and settling the scientific question upon purely scientific grounds, they mixed up the two, and the Birmingham so-called standard burner is the result. In saying what I have said, I do not mean to impute anything like dishonesty of purpose to the late Mr. Hughes, or any for whom he was concerned. They acted at that time as they thought rightly, but I mention it as an example of the folly of allowing party questions to be imported into scientific research. All they wanted was 14-candle gas at a certain price, and the company wanted to supply 14-candle gas at a price based upon calculations made and believed in by them. If they or their opponents were uncertain as to what was 14-candle gas, it would have been much better and more dignified to have settled the question of the burner first. I trust you will not think I am saying all this needlessly. If it were not that at the present day the very same line of conduct is continually persisted in, I should have left the Birmingham burner without a remark. I am of opinion that the very first thing to settle is the testing-burner, and afterwards the price of the gas.

Now, if you will examine the burner, you will readily trace the conflicting principles in it. Thus the top is to be of metal, and flat, because the type of burner selected by Mr. Hughes was an old Argand iron-top burner, of the size called No. 6, originally intended for 30 holes, but drilled with only 15 holes, and flat on the top. The enlargement of the holes to ·050 was done by myself to modify its destructive property. It will be observed that the centre opening is truncated; here we again have the destructive principle, for the original No. 6 has an opening of $\frac{5}{8}$ of an inch, being straight all the way up. The principle of development is due to Dr. Letheby, and consists of a narrowing of the centre opening at the top.

The destructive principle is again apparent in the suppression of the perforated regulator, which was supposed by Mr. Hughes and party to exercise a marvellously improving effect upon the burner; whilst, lastly, the substitution of the metal top, composed of hard bronze, was a sublime effort of genius on the part of your humble servant, the burner maker.

The result is confusion. The burner is totally unfit for the use of the consumer, whose fingers it will assuredly burn most effectually if he attempts to touch it after it has been alight for some time. It is equally unfit for testing purposes being only capable of *consuming*, without smoking, exactly 5 feet per hour, of exactly 14-candle gas when new. It possesses the extraordinary faculty of decarbonating the gas burned through it, and depositing a part of the carbon in little heaps just between the holes. A fatal objection to it, as a standard burner, is that the size of the holes alter by the action of heat and the deposited carbon. It does not develop the full illuminating power of the gas, yet, notwithstanding all this, it was adopted as the testing burner for Burslem, Hanley, Potteries, and Brighton. The latter town has, however, succeeded in getting rid of it, but the other places are, I believe, still afflicted with this objectionable burner.

The Leamington burner, of which you will observe there is a diagram, is a long-chambered Argand, with a steatite top and 15 holes, and, like the Letheby burner, it has the perforated disc for the regulation of air. I may here state that the air-regulator was never supposed by me to have any effect towards increasing the illuminating power. It merely prevents the four arms, which support the gallery, from marking their presence on the flame, which they otherwise would, by four depressions, one over each arm.

Dr. Whitmore conclusively established this fact when he made a quantity of experiments for the Marylebone Vestry, with a view of settling upon a standard burner for testing the gas supplied to them by the Imperial Gas Company. The burner settled upon, which I call the Imperial burner, is the same as the Letheby burner, with a slightly larger central aperture. This, however, never became a parliamentary standard burner, because the bill promoted by the Imperial Company, in which it figured, shared the fate of a great many other "innocents."

One remark must be made, however, with regard to the Leamington burner. It will be observed that it has only 15 holes, although the ring of the holes is much larger than the 14-candle burner. I need not point out to you that this is one more of the muddles which one gets into by endeavouring to apply a

fixed rule to varying circumstances. If 15 holes be right for the 14-candle burner, it is manifest that the holes being wider apart in the 18-candle burner must exercise a destructive effect upon the gas—18 holes would have been much better. In this case, however, as in the case of the Birmingham burner, probably the like cause produced like effects.

We now come to the Dublin burner for 16-candle gas. This, you will perceive, is similar in form to the Letheby 14-candle burner, the central aperture only having been increased for the admission of more air to the richer gas. Some mistake appears to have been made in describing this burner in the Dublin Gas Company's Act, for the dimension there given for the central aperture is ·60, the same as the Leamington for 18-candle gas; and, in consequence, the company was compelled to come to Parliament to get it altered. I shall perhaps have to speak further of this in another place.

I now pass on to another epoch in the history of standard burners, in which the principle of development has exercised a very powerful effect upon the settlement of the question of the illuminating value of gas. In 1868 the gas referees appointed under the Metropolis Gas Act, as you are all doubtless aware, advertised for a burner conforming with certain principles laid down by that parliamentary committee on the Metropolis Gas Bill known as "Mr. Cardwell's committee." As the effect of the action of that committee has been, and doubtless will long continue to be, felt by all gas companies, not only in London but throughout the kingdom, it will be as well if I give you those principles.

They embody the definition of what a standard burner ought to be, and take into consideration not only the interest of the consumer but also of the gas company or seller of gas. For the first time then we see the question divested of party feeling, and placed upon purely scientific grounds. The requirements were, that it should be the best for developing the illuminating power of the gas supplied by the seller, and at the same time the best for the use of the consumer.

The London Burner was accepted, a diagram of which is now before you. You will see that it differs from all the preceding ones in several important points. First, the holes through which the gas escapes at the point of ignition are, in number and size, so arranged that every jet blends, and the area of the sum of the holes on the top exceeds so far the area of the three holes by which the gas enters into the combustion chamber, that the gas which has been admitted is allowed to escape without pressure. By this means it is consumed as a natural flame similar to that of an oil lamp. The oxygen of the atmosphere combines by affinity with the hydrogen and carbon of the gas, while the nitrogen is permitted to escape freely. The quantity of air required to pass up through the chimney of the London burner for the development of 5 cubic feet of 14-candle gas may be roundly stated as 50 cubic feet, or nearly ten times the volume of the gas; of this probably the greater portion goes up through the centre aperture. Its velocity, as it passes out of the top of the chimney, will therefore be about 1100 yards per hour, or a little under two-thirds of a mile. The quantity of oxygen in the 50 feet of air is 10½ cubic feet, and the remaining 39½ are nitrogen with about 1 per cent. of sulphur and carbonic acid mixed with it. Two cubic feet of pure oxygen would properly consume the 5 feet of gas if applied to it through the chimney, and less than that if intimately mixed with the gas—a highly dangerous proceeding which I have not verified out of respect to my own safety.

You will see that more than half the oxygen passes through the burner unaffected.

If we attempt to make this escaping oxygen come into contact with the flame by means of deflectors, we destroy the illuminating power, because we not only deflect the oxygen, but the nitrogen also. The destructive effect of the nitrogen is so great, that the heated particles of carbon are extinguished and blown up the chimney unconsumed, without having had a chance of becoming sufficiently incandescent to develop any illuminating power at all. This is the destructive principle. The object, then, of the London burner is essentially to consume the gas as a natural flame. How it succeeds is abundantly proved in the case of those gases which, from their richness or admixture with very light hydrocarbon or atmospheric air, will not bear a great velocity in the current of

the gas or air supplied to them. For example, the gas produced by impregnating atmospheric air with very light hydrocarbon, so energetically attempted at the present time by so many inventors, can only be properly consumed by the London burner, which, by the low initial velocity it gives to the gas and air, allows the nitrogen in the air to escape easily, and gives time to the carbon and oxygen to unite together.

The entry of the gas to the burner is effected through the screw regulator, as shown. The inverted cone opens or closes the passage according to the number of card washers which are placed on the shoulder of the cone, which is screwed on the chandelier, or the fitting to which it is fixed. The effect of this regulator is to lower the velocity of the gas, so that it may enter the combustion chamber at the lowest practicable velocity.

If the gas were allowed to enter this combustion chamber with any high velocity, it would be impossible afterwards to reduce it, and destruction instead of development would be the consequence. When the London burners are employed by the consumer, it is usual to maintain the uniformity of pressure at the meter by means of an ordinary governor, and to regulate the quantity required to be consumed at the point of ignition by means of the screw adjustment here shown. This I call double regulation. The new London self-acting governor Argand is provided with a small dry governor in the place of this regulator. One of these burners is also shown. It will maintain a constant height of flame under variations of pressure from 7-10ths to 2 inches; after that it decreases the consumption a trifle. It also is provided with a screw adjustment on the top of the governor, by which the consumer may readily adjust the quantity he desires to burn.

The identical kind of burner used to test the illuminating power of the gas is made use of to great advantage by the consumer, and he is enabled to get the full value in light for the quantity of gas he consumes.

Thus, the standard burner is a guide to him how to consume his gas to the best advantage, and when he is told that the result of the official test is 14, 16, 18, 20, or 27 candles, he knows that he can by its means obtain just that amount of light for every 5 feet of gas he burns.

Previously to the introduction of the London burner, it is well known that the light obtained by the consumer from 5 feet of gas bore no proportion at all in the generality of cases to that stated by the official gas-testers.

Notably so in the case of 12 or 14 candle gas, for the consumer generally obtained only one-half the amount of light, owing to the destructive properties of the burner he employed.

Commercially, the value to the consumer of the London standard burners may be thus shortly stated:—

Compared with the oil lamp standing on this table, which evolves the most light that can be obtained from colza oil, being about 15 to 20 per cent. more than can be obtained from the same quantity of oil consumed in any well-constructed moderator lamp. The result is as shown in the following table:—

COMPARATIVE COST OF LIGHT

produced from gas burned through the "London" standard burner:	produced from ordinary colza oil burned through a moderator lamp of best construction:
24 feet of 23-candle gas will give a light equal to 10·5 parliamentary sperm candles of six to the pound, and cost, at 7½d. per 100 cubic feet in London, less than 2d.	One pint of oil consumed in 12 hours gives an illuminating power of 10·5 parliamentary sperm candles of six to the pound, and costs 6d., or three times the cost of gas.

For cannel gas, the only burner which may be called a standard is that used for testing the cannel gas supplied to some parts of London. This is called by the gas referees in their instructions to the gas examiners "Sugg's steatite bat'swing, No. 7."

A drawing of it in section is exhibited. The quantity it is required to consume for the purposes of testing the illuminating power is 5 cubic feet per hour.

The pressure at the point of ignition when it is passing that quantity of gas is 3½-10ths.

It is made use of for testing gas of from 22 to 25 candles illuminating power.

The "Dublin" burner for cannel gas, of which there is a drawing, is one which has been agreed upon between the Corporation of Dublin and the Alliance Gas Company for the purpose of testing the gas supplied to the city. You perceive it is a double-current flat-flame burner. It is made to consume 5 cubic feet of gas per hour, at a pressure at the point of ignition of 5-10ths.

The gas which it is intended to test is stated in their bill to be 20 candles.

Now there are several very important points connected with this burner and the preceding one, to which I wish to draw your attention.

First, you will notice that the pressure at the point of ignition is in both burners very high, as compared with that used for testing 16-candle gas—viz., the "London." According, therefore, to my theory—which, of course, I believe to be the only right one upon the subject—they neither of them comply with the requirements of Parliament as laid down by the "Cardwell committee." They do not develop the full illuminating power of the gas which is tested by them, and therefore they ought not to be accepted as standard burners by the official gas examiner, neither are they at the same time the best burner for the consumer. Excepting for a butcher's shop, or where a great flare is required, regardless of unconsumed gas, they cannot be said to be made use of by the latter.

Five cubic feet of rich gas per hour is, I think, too much to be conveniently and properly consumed in one burner.

The least agitation of the air causes these burners to give off partly consumed gas, and in consequence a great quantity of lamp-black of a not very superior quality is gently distributed over all the ceilings and furniture in rooms where they are made use of. This last remark applies not only to them, but to almost every kind of cannel burner in use. Hence the idea that cannel gas requires strong pressure at the point of ignition. Of course it does if you will persist in burning the gas in a burner of such a form that the oxygen of the atmosphere cannot combine with it by a natural affinity. If there were no pressure at the point of ignition of a flat-flame burner the flame would be in a mass, and the oxygen could not get to it; pressure is required to blow it out into a flat flame, and so the particles of carbon are driven out like a regiment of soldiers extending out into skirmishing order, separating farther from each other the farther they go, until they either meet with oxygen to combine with them or nitrogen to extinguish them. Carry out this experiment to its ultimate result, and you will find that the illuminating power of the same quantity of the same gas burned through a series of different flat-flame burners will go on losing its illuminating power as the pressure at the point of ignition increases, until it ends in complete destruction. Now, look at your enemy, the moderator lamp. I suppose no one will deny that the gas being evolved from its wick, and consumed as rapidly as it is made, is not of a richer quality than even the Edinburgh cannel gas is, and yet it is consumed without pressure at the point of ignition.

Petroleum gas is richer still, and yet in Hinks and Wells's duplex lamps you have a light equal to 16 sperm candles evolved without pressure at the point of ignition, but at a little more than *double* the cost of 16-candle gas in London. I may as well state in passing that here in Edinburgh the cost of this beautifully rich gas is such that the enemy is left far in the rear, and so the Edinburgh folks can afford to waste some of their illuminating power. But even here the enemy has one advantage over you. If you disregard waste you must use more gas to produce the same amount of light, and the more gas you burn the more heat you evolve. So the lamp which gives the greatest amount of light with the least consumption of gas is preferred very often for this very cause, although it costs more. Yet, again, since the days of Argand, a host of inventors have put into action for the benefit of the lamp an enormous amount of ability and talent, and no expense has been spared to push forward the lamp to its extreme limit of perfection. And good reason for it, for the aristocratic lamp has had to strive against a powerful plebeian adversary. Art and science have both done their best for the genteel lamp. Gas, on the other hand, has been left to blaze itself into general use the best way it can by its great merit, cheapness, and constant readiness. I have now the honour of addressing a body of men who possess among them an amount of theoretical and practical science in relation to gas unequalled in the whole world, who have literally, not poetically, toiled day and night to bring the science of artificial illumina-

tion to its present state of excellence, and who have always been and still are the leaders throughout all the world of those whose vocation it is to continue the blessing of light to a large portion of the civilized human race, when the sun has, in poetical language, sunk to his rest. Yet the toil of your brain and the labour of your hands at the retort and purifier are, to a large extent, nullified at the culminating point by a miserable little bit of iron worth less than a farthing. There is yet another point on which the question of the proper standard burner for cannel gas touches you nearly. We speak of 20, 25, and 30-candle gas, &c.—to some people *ad nauseam*.

But can any of you tell me what 20-candle gas is? In London we are told that 5 cubic feet per hour of 23-candle gas will give a light equal to 23 sperm candles, &c., when burned in a burner which requires 3½-10ths at the point of ignition to get this quantity out of it; and this is 23-candle gas according to the gas referees. If so, then what quality is the gas supplied to the city of Dublin, 5 cubic feet of which will give a light equal to 20 candles when burned through their *so-called* standard burner under a pressure of 5-10ths at the point of ignition? If what I have told you is true, that pressure at the point of ignition decreases illuminating power, can it be possible that the gas is anything like 20-candle gas? Without a doubt, if the cannel gas supplied to London is a true 23-candle gas—I say it is certainly that, if not more—the Dublin gas must be very much more than 23 candles. Now you will see at once that there may be a very wide difference in the estimated cost of gas called 20 or 30 candle gas, unless you know very well beforehand what your burner is going to do for you. I think this will account in a great measure for the conflicting statements before committees of the Houses of Parliament, which put our worthy legislators so frequently in a state of bewilderment with respect to gas matters. I give more prominence to these facts than I otherwise should, because, if the example of the Dublin Gas Bill is to be followed, we shall be farther than ever from any satisfactory definition of the relative illuminating power of gases produced from different sorts of coal or other materials.

Having now arrived at the conclusion of my description of standard burners, you will naturally ask me why, considering that I have made nearly all the burners that have been used for gas-testing since about 1860, I have not made them better. I at once reply that, with the exception of the London burner, I have always been fettered by restrictions as to the size of the burner or number of apertures, &c., which have been already fixed by previous old Acts of Parliament, or by agreement between the adverse parties, before I have been applied to.

Now as to what can be done for the future, for I hope that we are not always to go on in the present unsatisfactory manner. I think that the selection of standard testing-burners for different qualities of gas is as important as the settlement of the sizes of a standard cubic foot measure or the length of a 2-foot rule. It is, in fact, a Board of Trade question, and should be settled by the proper officers appointed by the board—viz., the gas referees or the Standards Department. With such eminent talent as is possessed by the present board of gas referees, they can scarcely fail in arriving at a satisfactory result, if they take up the question. I can only offer to point out what I imagine would be a very good way of dealing with the question, viz.:—

1. To test all gases for illuminating power with an Argand burner; no pressure at the point of ignition.
2. To fix the rate of consumption at the burner by the following scale:—
   12-candle gas, 6 feet; 14-candle gas, 5 feet; 16-candle gas, 4½ feet; 18-candle gas, 4 feet; 20-candle gas, 3½ feet; 25-candle gas, 3 feet; 30-candle gas, 2½ feet.

About three Argand standard burners will then be all that is required for all these gases; or, in another way, one only might be used, burning the flame up to a certain fixed height in the glass, and then give a table of illuminating power ranging from the lowest consumption required to give the proper height of flame to the highest, calculated after the rate of 5 cubic feet per hour.

The adoption of either of these systems, more particularly the first, would enable us to give the proportionate illuminating power of every kind of gas, which we cannot do under present circumstances. Now common gas is tried

by an Argand burner, and cannel gas by a flat-flame burner; consequently, from 18 to 20 candles, we are in a state of doubt as to when to leave off with the Argand and when to take up the flat-flame. Moreover, when we test with an Argand our readings on the photometer show the amount of light which can be got from the burner in any direction, while when we test with the flat-flame burner we get only the greatest amount of light which can be given from the flat of the flame. Thus, strictly speaking, the Argand may be said to light a circle and the flat-flame an oval of greater length as compared to its width, as the flame is broader or narrower.

Great difficulty is therefore felt by gas engineers in estimating the relative value of cannel and common gases, and the consumer has at present no guide as to the best way of using the gas supplied to him.

If we look again to the enemy we shall find that custom has determined that the size we have before is that which most effectually supplies the requirements of those in need of artificial light from oil, and guides to the proper amount of light from each point of ignition. Too strong a light in one point is not good; it is required to be well diffused in order to minister properly to our comfort. Now the amount of light given by this lamp in good burning order is 10·5 candles. This, in my opinion, is rather weak for gas. Every one expects more light from a gas-burner than from oil. Now if we take the scale I have formerly laid down we shall get a burner of 13 to 14 candles each, no matter whether the gas is 12-candle or 30.

With the other form there would most likely be no greater difference than half a candle with any of these gases. Now these, I presume, are exactly the condition the consumer requires to be fulfilled. He wants to pay no more for his light, whether he is supplied with rich or poor gas; he wants a certain amount of light at a certain price per candle of illuminating power, and these standard burners would, in my opinion, show him how to get it.

It does seem rather curious that, although in every other invention that has been submitted to the public, even if it is only a mousetrap, full directions have always been given by the seller how the buyer is to make use of it to the best advantage, yet in the matter of gas the latter has been left almost in every case to his own devices.

In conclusion, I regret that I am unable to do more than shadow forth a system of standard burners; but that is as far as I have got at present. I am continually working at it, and hope in time to clear away the difficulties in the path, and work out a system of photometry suitable to all kinds of gases, more accurate than what we at present possess.

If, as is most probable, any statement or remarks I have made may not accord with the opinions of those among you who have given some considerable attention to the subject, I shall be glad to enter into further explanations with a view of either converting you to my notions, or of being corrected myself.

COMBINED SELF-ACTING BYE-PASS AND COMPENSATOR.

By Mr. D. Laidlaw, of Glasgow.

The exhauster having come into very general use not only in large and extensive gas-works, but also in works of comparatively limited extent, it has become a matter of considerable importance to have a simple and effective machine to regulate and modify its action, and so maintain a steady and uniform degree of pressure or vacuum on the hydraulic main and other apparatus.

Amongst the numerous and varied contrivances that have hitherto been proposed for this purpose, the majority have aimed at accomplishing this through the medium of the throttle-valve, expansion-valve, or governor of the engine; these being attached by suitable mechanism to a bell or small gas-holder, which, being acted on by the vacuum created by the exhauster, regulates and controls the speed of the engine to suit the quantity of gas being produced. These arrangements are all more or less effective, but are not

always sufficiently quick and sensitive in their action to prevent considerable variations in the pressure.

In many cases, also, especially in the smaller-sized works, where power is required for other purposes, such as driving pumps, &c., it is undesirable to vary the speed of the engine to any great extent, in which case a compensator is adopted.

In neither of the above arrangements, however, is any provision made for a sudden stoppage of the exhauster through any derangement of the engine, or other causes, this having to be provided for by a separate bye-pass valve.

In the machine which I now propose to bring under your notice, an illustration of which is hanging on the wall, the compensator and self-acting bye-pass valve are combined in a simple and efficient manner. Its action will be easily understood by reference to the drawing.

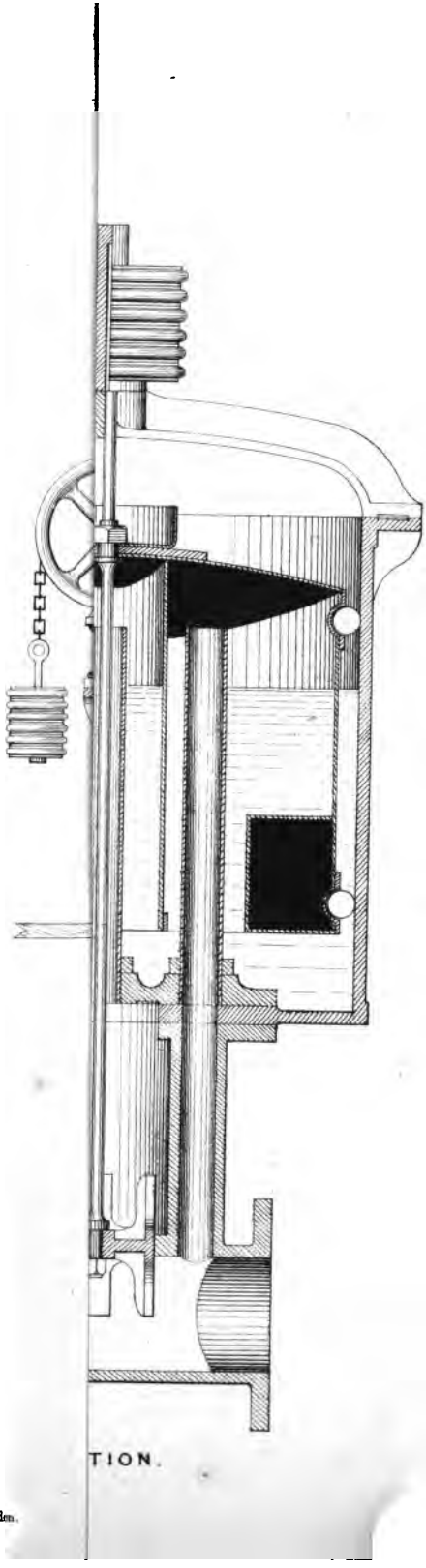
The machine may be placed in any convenient position, and the flanged branches A and B connected to the vacuum and pressure sides of the exhauster, A being attached to the suction, and B to the delivery side. The valve C is a flat disc, with prongs cast on each side, that act as guides when the valve works up and down in the bored-out seat to which it is fitted. This valve is attached to the bell or small holder D by a rod F, so that when the bell is moved upwards or downwards by the action of the exhauster the valve has a corresponding motion, and opens or shuts accordingly.

The bell is suspended by chains passing over pulleys, to which are attached weights sufficient to counterbalance the weight of the bell with the rod and valve attached to it. In some cases a beam with back balance-weights is used, and in the smaller-sized machines an air vessel or float is by preference adopted for the purpose. Thus, by increasing or decreasing the balance-weights, any required degree of pressure or vacuum can be readily obtained.

The weights, marked M, suspended from the cross-beam, through which the guide-spindle passes, are in a state of rest when the machine is acting as a compensator, and are not intended to come into operation until it is required to act as a bye-pass valve. The number of these weights varies according to the pressure in the works, in no case exceeding, but being rather under, the general pressure. Each weight may be taken to represent an inch of pressure. The action of the machine, it will thus be seen, is very simple. When the speed of the exhauster is greater than is required for the make of gas at the time, a slight vacuum is produced, which, acting through the pipe E on the crown of the holder D, draws it down, the valve at the same time being opened by the rod F, allowing the gas to return back from the pressure side through the valve in the direction of the letters B C A, thus restoring the pressure and shutting the valve, the weights M acting as a stop to prevent the valve from rising too far and opening on the opposite side.

On the other hand, should the exhauster stop from any cause whatever, the pressure immediately rises in the hydraulic main to the general pressure in the works, and this acting again through the pipe E, on the crown of the bell, presses it up against the weights M, and raises them, and at the same time opens the valve on the bottom side the necessary amount, allowing the gas to pass freely through in the direction A C B. It thus forms a perfectly self-acting bye-pass, without adding any additional pressure to the gas whatever. When the exhauster has again started, the weights acting on the bell press it down, and shut the valve, forming the necessary abutment between the inlet and outlet sides. The weights again rest on the cross-beam N, and the machine begins to act as a compensator as before.

It may be further observed that, as the valve C is, as a rule, made of the same diameter as the exhauster connexions, it has only to travel a very short space to give a large and sufficient opening for the gas to pass on either side, thus preventing any under vibration of the bell, or disturbance of the water in the lute. The pressure on the top side of the valve C is exactly counterbalanced by the pressure acting through the pipe F on the circular space of the crown of the bell, which in all cases is made the same area as the valve, and preserves it in perfect equilibrium, and as the friction is almost nothing, and there being no stuffing-boxes or spindles to set fast or get out of order in any way, the action of the machine is exceedingly sensitive, so that the slightest variation in pressure acting on the annular crown D of the bell, which is of large area, has at once the desired effect.



TION.

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UNIV. OF MICH.

This machine, therefore, possesses the advantage of combining the two very important functions of compensator and bye-pass; it is very simple and strong in construction; is not liable to get deranged; is very sensitive and uniform in its action; and is thoroughly self-acting, requiring no attention from any one, either at stopping or starting. It is, in fact, a perfect *exhauster safety-valve*, and is consequently peculiarly fitted for works where close attention cannot be given to the exhauster-room. It is also specially adapted, from its great steadiness of action, for working along with any kind of exhauster, where the flow of gas is irregular at different portions of the revolution, and where consequently the pressure-gauge is unsteady.

These results are not founded upon mere theory, but are based upon an experience of the practical working of the machines, sufficiently long to justify the statements I have had the honour to lay before the members of this association.

CONSTRUCTION AND THE CHOICE OF MATERIALS FOR GAS APPARATUS.

By Mr. R. Dempster, of Elland.

I am not aware that this subject has ever been treated at any of our meetings, and I have, therefore, chosen it for a new line of thought.

It would be too lengthy a paper to consider this subject through all the departments in gas manufacture. I will, for the present, consider only what we call the carbonizing department; and at some future meeting, either I, or preferably some other engineer more able than myself, may deal with this subject beyond this point.

First, then, I shall consider from the retorts or furnaces up to and including the chimney, but I shall not notice the retort-beds and settings, because many capital papers, with drawings, have already been given at our past meetings, and to tread the same ground again would be unprofitable. Besides, I consider every manager knows his own requirements best, whether they should be beds of fives, sixes, or sevens. It is no uncommon thing for many architects, engineers, and managers, in preparing plans and specifications, to take little notice of the selection of materials best adapted for the different objects they may have in view, but simply to go on treading in the beaten track of their forefathers.

With regard to gas apparatus and gas manufacture, the materials generally selected for the retort-bed are perhaps the best and most defined, for they are narrowed down to a very small number—viz., common bricks and fire-bricks; nor has nature or science yet discovered anything to substitute or assist either of them, therefore they are well defined; for none can dispute the refractory properties of fire-bricks as the best material known at present for standing fire. Fire-bricks owe their refractory properties to the large per centage of silica they contain, and this property increases in proportion to the absence of lime, oxide of iron, magnesia, &c This property is greatly increased if a proper quantity of ganister is ground up with the fire-clay. The peroxide of iron usually takes the form of little black specks or mottled particles which are embedded in the material, and can be plainly detected upon breaking the brick. When ganister is mixed with the fire-clay, they are called ganister bricks; they are best adapted for the furnace linings and settings, but as ganister renders the brick soft, I find it is unadvisable to build the retort-beds with them. It is a well-known fact that, until the ganister fire-brick was discovered, the furnace-linings of iron and glass works, whose heat is far more intense than that of gas furnaces, were generally burned out about every two months, whereas now they will last double that time.

It may not be generally known that there exists in nature two kinds of fire-clay, and though often found in the same locality, and, indeed, under the same soil, yet they are very different in their nature and appearance. The

top bed is of a rocky nature, bluish in colour, and not much softer than ordinary sandstone, and in general has to be blasted in the workings. This kind of fire-clay differs in many ways from the lower bed; firstly, when made into a fire-brick, and while under the cutting heat of the furnace, it never expands, but diminishes in size until the joints become very wide; secondly, it stands the fire much better than the lower bed, probably owing to the small per centage of peroxide of iron and lime contained in it. This top bed of fire-clay averages about 65 per cent. silica, 32 per cent. alumina, and 3 per cent. of peroxide of iron, lime, magnesia, &c.; thirdly, it is not at all adapted for the manufacture of retorts or bricks for brick retorts, for these particular reasons—first, owing to its liability to contraction; secondly, on account of its very porous nature, so porous, indeed, that when retorts are charged for the first time, it is no uncommon thing to find that there has not been any gas made, though not a particle of leakage is to be seen about the retort. In some cases I have seen the second charge nearly spent before gas-making has commenced. I can only account for this strange phenomenon by the affinity of the fire-bricks for the carbon. Absorbing it as it is made, and continuing to do so until it is fully charged. I may say that I have seen retorts that have been broken and pulled out, having been charged only once or twice, fully charged with carbon in their section. Another feature in this fire-clay is that retorts made from it are liable to become rapidly covered with carbon where no exhauster is used.

The white or lower bed of fire-clay is generally found from about 40 to 120 feet below the top bed. It is more plastic in its nature, occasionally, the same as common red clay. The bricks or retorts made from it expand under heat, so much so that I have seen four strong cast-iron stays broken in one single bed of brick retorts. The expansive nature of this clay is probably due to a less per centage of alumina than in the former, and a larger per centage of silica, lime, magnesia, &c. This fire-clay contains about 74 per cent. of silica, 22 per cent. of alumina, and 6 per cent. of peroxide of iron, lime, magnesia, &c., and it is best suited for the manufacture of fire-clay retorts or bricks used in constructing brick retorts where the property of expansion is an advantage.

Ganister is a hard siliceous rock found in many parts of England. In appearance it resembles ordinary sandstone; it has great refractory properties, standing nearly as high as the Dinas rock found in the Vale of Neath, Glamorganshire, it having about 95 per cent silica; it is used in certain proportions with fire-clay. The bricks made in this way are very soft, owing to the diminished per centage of alumina to bind the particles together. The bricks are so soft that the edges cannot be retained, and are easily broken in transit.

It is not advisable to build the first course above the grate bars of the furnace with them, owing to the mechanical action of the stokers bar. From their extreme tenderness they will not likely prove a success, unless they get into the hands of skilful workmen. These bricks are held in high reputation in large iron and glass works.

But whatever great advantages fire-bricks may have in the retort-bench, nowhere are they more so than in the retort-house chimney, and nowhere is the selection of materials more neglected. Now, as fire-brick is one of the best non-conductors of heat, it recommends itself to us as the best adapted for the lining of our chimneys. Its action is as follows:—Being a non-conductor, it retains the heat within itself, consequently the interior or lining of the chimney rarefies the air within it, causing it to pass up the chimney at a greater speed, and as nature abhors a vacuum, so must the air rush in through the furnace to fill the vacuum. Hence the reason for the draught. I think it advisable that chimneys should be lined with fire-bricks at least 4½ inches thick to the top, the difference in cost being so trifling in comparison with the permanent advantages gained.

I have no hesitation in saying that the retort-house chimney has more to do with the results in carbonizing than is generally supposed, and that, in my opinion, from 500 to 1000 feet per ton may be the difference between a good and a bad chimney.

Red brick is a better non-conductor than stone, and they stand relatively nearly as 1, 2, 3. Having tested the draught of a chimney built entirely of

stone, another of stone lined with common bricks, and a third of stone lined with fire-bricks to the top, the proportions of the chimneys being nearly the same, the results obtained were as follows, viz :—

1. Stone	5-10ths	draught.
2. Common bricks	10-10ths	„
3. Fire-bricks	15-10ths	„

And this is the most I have ever been able to get from any chimney, however high.

Again, we occasionally see another fashion introduced by some architects. We very often see a very high and beautiful chimney, high enough and wide enough for double or treble the work for which it was intended, and was no doubt erected for the purpose of causing a draught; but, on looking near the bottom, you will find six or eight gratings round the base, and inside you will find air channels proceeding inwardly just behind the lining, and then proceeding upwards nearly to the top of the chimney. I have seen such a work pointed to as a great achievement, an important discovery, and worthy of imitation; and if you ask why it has been so constructed, you are modestly told it is to keep the chimney cool, in one sentence showing that nothing is known of the materials dealt with nor of the common laws of nature.

Now, it must be obvious that a vast amount of money is wastefully expended to accomplish an object, and by one false act it is entirely destroyed—viz., by cooling that part which requires to be maintained at the greatest possible heat. It has been said by some that these openings admitting air prevent the chimney from cracking. This may be so, but it is an expensive way of doing it; and, for the benefit of those who may adhere to this idea, I would suggest the closing of the bottom air channels entirely, and they would then have the pleasure of seeing their chimneys maintain their entirety, and also the pleasure of seeing the work of the chimney wonderfully increased.

Chimneys built internally on this annular principle are good, inasmuch as they keep the inner lining independent of the outer building, and thus prevent the cracking.

In constructing a chimney, the following rules may be adopted with advantage—viz., that for every retort to be heated not less than 25 inches of air space is required in the grate-bars or furnace, or, in other words, for a bed of five retorts 125 inches, and for a bed of seven retorts 175 inches of air space. Now, as the minimum temperature at the end of the retort-bed, or between the retort-bed and the chimney, is generally found to be about 750° Fahr., and assuming the air to be 50° Fahr. previous to entering the furnace, there is left 700° Fahr. for expansion, and as air expands about $\frac{1}{4}$ per cent. for each degree of temperature, the actual space required for each bed of 5 retorts at work will be 220 inches, and for every bed of 7 retorts at work 308 inches.*

But how often do we find a retort-house chimney expected to be fit for more than double this amount of work. Its power is never consulted, but so long as it stands it has to do the work set apart for it, and often the engineer and the retort-setter are blamed for their performance if the retort should fail to heat.

Serious mistakes have been made where the chimney is placed at some distance from the retort-bed, and the main flue carried towards it underground, by allowing the earthwork to come in contact with the sides of the flue. The moisture of the earthwork is continually drawn towards it by the action of the heat, thereby cooling it and seriously injuring the draught. This may be obviated by having a burr wall on each side, the faces of which should be say 5 or 6 inches from the flue, or should this be considered expensive, then excavate say 12 or 13 inches each side the flue, and fill up the space with rubble stones, say about 3 inches square. The object in either case is to prevent the earthwork coming in contact with the flue. Many a bad draught has been remedied by either of these applications.

Now, in these days of high-priced coal and labour, every engineer and

* Since writing the paper I have tested some chimneys, in one of which I found the maximum to be 2500° Fahr., but at this point the top of the pyrometer was seriously injured.

manager needs to inquire into, and not rest contented till he is satisfied that he is right at all points; otherwise he will find that he cannot comfortably compare notes with his professional brethren, and will be misled into laying blame to that to which it does not attach.

Now, then, as to the height of the chimney. This is a point upon which there may be a greater variety of opinion than in the former, and perhaps more complicated, inasmuch as fire-bricks are not all alike good non-conductors. It may be asked, "What use is the chimney at all?" and a very proper question too. This brings to my mind a circumstance which occurred when I was with the Phœnix Gas Company, London, nearly twenty years ago. The then respected superintendent of the Greenwich station had something wrong with his retort-house chimney. Having top draughts to all his settings, he at once took off one or two flue covers from each bed of retorts, and to my astonishment as well as his, he maintained very good heats, and his results were very little short of those obtained with the aid of the chimney—indeed, they were better heats than some I have seen with chimneys considerably over 100 feet high. And I have no hesitation in saying that a chimney is often a hindrance rather than a benefit. But as to the required height, we shall endeavour to arrive as near as possible at a fixed point. Seeing, then, that a fair, though not a first-class heat can be maintained without a chimney, and that with a bad, yet even high chimney, no better heat can be produced, where then is the point to fix a definite height? As I said before, it seems that the extreme height of the chimney has nothing to do with, and cannot increase the draught beyond a certain point—viz., 15-10ths. I may say I tested a very good chimney, some few weeks ago, 300 feet high, and it only gave 15-10ths—no more than you may obtain from a chimney, properly constructed, 50 feet high. The height in excess can only be advantageous for carrying the vapours to a higher level, especially where coke is employed, as the vapours from coke are more destructive to vegetation than from coal. And it may be said by some that very good heats can be maintained by chimneys even under 50 feet high. This may be so, as I said before, owing to the difference in the nature of the fire-bricks and its good construction, when even a higher temperature than 750° Fahr. may be delivered into the chimney. The temperature of a chimney varies very much. When at the bottom you may find 750° Fahr., at a height of 50 feet it will be about 550° Fahr., at a height of 100 feet it will be about 350° Fahr., and at a height of 150 feet it will be about 200° Fahr.

In conclusion, I have confined my remarks, as I said at the outset, strictly between the two points—the furnace and the chimney; and as I consider the subject so extensive as to furnish a series of papers, I trust some other engineer will either take up the continuance of the subject, or take part along with others in doing so.

NOTES ON THE METHOD OF CALCULATING THE FLOW OF GAS THROUGH PIPES.

By Mr. J. Paterson, of Warrington.

The committee last year placed upon the paper of subjects recommended for the consideration of members, amongst others, "The best Method of Calculating the Flow of Gas through Pipes." I have, at the request of a few friends, and without presuming to lay claim to a profound knowledge of the subject, ventured, on behalf of younger members of the profession, to add a few brief notes thereon.

It is difficult to over-estimate the importance of an accurate knowledge of the flow of gas through mains, which, in the hands of a gas engineer, is an element of constant application. To apprehend and formulate the laws carried on by natural forces, he must adopt tentative methods by collecting data, some of which are constant, others variable. The gravity and weight of the atmosphere are constants, whose value has been long established. The

pressure on the flowing gas, the length of pipe, the diameter of the same, its inclination with regard to the level and interior smoothness, and the specific gravity of the gas, are all variables, the value of which has to be found by experiment. The specific gravity of the gas and the pressure applied are important factors, and any error in one or other of these will materially affect the results. The physical laws which govern these calculations early attracted the attention of engineers, and after the experience of half a century it can hardly be said they are yet perfectly understood. The first investigator of the motion of gas in pipes appears to be M. Girard, a French engineer, who, in 1821, conducted a series of observations on tubes about half an inch diameter under different lengths and pressures, the results of which, though interesting, were of little practical value. In 1827, D'Aubuisson conducted a more important series of experiments on the quantities discharged through tubes of 2 inches diameter under various lengths and pressures, and of different specific gravities, from which he constructed a formula as applicable to the discharge of gas under different densities and diameters of cast-iron mains. The calculations of this engineer being founded upon the flow of gas through short tubes constructed of tin-plate, induced him to overlook the delicate but important principle of the loss of pressure by friction. The analysis of D'Aubuisson's laws may be briefly stated as follows, viz.:—

1. The discharge of gases under different degrees of density, when actuated by the same pressure, will be inversely as the square roots of their specific gravities.

2. The discharge through different sizes of pipes with gas of a uniform density, and actuated by a uniform pressure, is equal to the squares of their diameters.

To these the law of *friction* was added by Mr. Clegg, and published with D'Aubuisson's formula in the first edition of his Treatise in 1841. From a series of carefully conducted experiments, he found that the velocity of the gas varied in definite proportions with the length of the main, from which he deduced the following law, viz.:—That the quantities of gas discharged in equal times under the same pressure and for different lengths of main are to one another in the inverse ratio of the square roots of their lengths. Such was the state of this branch of physics up to the publication of Clegg's work. At that time the experiments had uniformly been conducted on pipes of comparatively small diameter, and the accuracy of the rules, as applied thereto, the writer had an opportunity of verifying in 1849, by operating on a 2-inch main 100 yards long; the gas, of a specific gravity ·665, was measured through a meter at the entrance to the main under an initial outlet pressure of 1 inch, and the discharge per hour was 1030 cubic feet. Thus, practically confirming the accuracy of the rules as applied to small mains, the measured and calculated discharges being equal, but as yet there was no proof of their applicability in the case of large mains.

In 1850, Mr. George Anderson, who was preparing plans for the erection of the Great Central works, was led to direct his attention to the delivery of gas through mains of large diameters, and he was the first to call attention, in an article contributed to the *Mechanics Magazine*, to the fallacy of the existing rules as applied thereto. The arguments are too long to be inserted here, but they may be resolved into the following abstract:—A 6-inch main of a given length and pressure is found to deliver per hour 4500 cubic feet; a 12-inch main, having four times the area of a 6-inch, is said to deliver 4500 × 4 = 18,000 feet; but as a pipe 6 inches in diameter is in circumference 18·8496 inches, four such pipes will be equal to 75·398 inches, while a pipe of 12 inches diameter has a circumference of only 37·7 inches. The rubbing surface is therefore in the proportion of 1 to 2, and in order to correct the error he proposed to multiply the result by the square root of 75, and divide by the square root of 38. In other words, he added the fourth law—viz., that under a given pressure, specific gravity, and length of main, the discharge will be in the inverse ratio of the square root of the rubbing surface.

In 1852, Professor W. Pole contributed to the JOURNAL OF GAS LIGHTING an article of great value on the laws which govern the flow of gas through pipes, in which the foregoing rules were adopted. This paper has been republished in the subsequent editions of Clegg, and may be studied by gas and water engineers with much advantage, possessing as it does probably all that is known and

reliable on the subject at the present day. The learned professor puts the equation in the algebraical form thus :—

$$Q = 1350\, d^2 \sqrt{\frac{h\, d}{s\, l}} \begin{cases} Q = \text{quantity of gas in cubic feet per hour.} \\ l = \text{length of pipe in yards.} \\ d = \text{diameter of pipe in inches.} \\ h = \text{pressure in inches of water.} \\ s = \text{specific gravity of gas, atmospheric air as 1.} \end{cases}$$

In which it will be observed the radical sign of the square root covers both the numerator and denominator; the meaning of which is, that in the *first* term the diameter of the pipe is to be multiplied by the pressure both in inches. That in the *second* term the diameter in inches is to be added to the length of the main in yards, multiplied by the specific gravity of the gas; the product is then to be divided by the results of the first term, and the square root of the quotient extracted. That in the *third* term the square root of the diameter of the pipe in inches is to be multiplied by the constant 1350, and divided by the result of the second term, when the quotient will be the quantity discharged in cubic feet per hour. It is not to be assumed, however, that the application of these rules will in all cases be mathematically correct. There are disturbing causes, such as the unequal roughness on the interior surface of the mains, and their perfect or imperfect jointing, which necessarily exercises an important influence on the *coefficient*, an element which theory affords us no assistance in determining. From an extensive series of experiments on the discharge through long pipes, conducted in 1867 under the superintendence of M. Arson, engineer for the Paris Gas Company, we find this element varying in a remarkable degree from the results of previous experiments made in this country. In small mains the friction under those experiments appears to be greatly increased, while, on the contrary, for large mains it appears to be greatly diminished. Without entering into particulars or in any way detracting from the importance and consideration such a series of experiments deserve, I cannot help thinking that, allowing for any irregularities in the jointing of small mains, or of exceptional smoothness in the internal surfaces of large ones, there should not be a difference so decided as that found in the coefficients resulting from these observations, and it might be desirable to wait their confirmation by further evidence before committing ourselves to the alteration of the constant already established. At the same time I do not wish it to be understood that I consider the formula acknowledged amongst us as not susceptible of further improvement. The advancing tide of science may place at our disposal the elements of a higher and more perfect practice, and as theory is deduced from the results of generalized practice, it is not improbable it may be elevated to a more pure and accurate form. There is still a paucity of observations amongst English and Scotch engineers on this interesting subject, and when opportunities present themselves it would be desirable, in the interests of science, to record the results of their experience. As a small contribution to received experiments on comparatively large mains, I give the results of some careful observations I had the opportunity of making last summer on the discharge through a 16-inch main under the following conditions, viz :—

Length of main 280 yards, containing four sweep-bends at an angle of 90°.

Height of the termination of the main above the exit from the governor, 17 feet 9 inches.

Pressure measured on the exit-pipe from the governor, 1 inch and $\frac{1}{2}$ inch respectively.

Specific gravity of the gas, 0·556 (air as 1).

The first of these observations, conducted under a pressure of 1 inch, indicated a discharge equal to 111,930 cubic feet per hour, and in the second case, under a pressure of 5-10ths, the discharge was 78,800 cubic feet.

If we apply the above conditions to the received formula—

$$Q = 1350\, d^2 \sqrt{\frac{h\, d}{s\, l}},$$

the calculated discharge does not differ very materially from the absolute results. Thus, let Q = 1350 cubic feet per hour.

l = length of pipe in yards, 280.
d = diameter of pipe in inches, 16.
h = pressure in inches of water, 1.
s = specific gravity of gas 0·556 (air as 1).

Then— . . . . . Log. 16 = 1·2041200

Log. ·556 = $\bar{1}$·7450748
,, 280 = 2·4471580 = 2·1922328

2)$\bar{1}$·0118872

$\bar{1}$·5059436

Log. 16 × 2 = 2·4082400
,, 1350 = 3·1303338

Q = cubic feet per hour, 110,794 = 5·0445174

The calculated discharge under a half-inch pressure gives also a close approximation to the results of experiment, thus . . Log. 16 = 1·2041200

Log. 2 = 0·3010300
,, ·556 = $\bar{1}$·7450748
,, 280 = 2·4471580 = 2·4932628

2)$\bar{2}$·7108572

$\bar{1}$·3554286

Log. 16 × 2 = 2·4082400
,, 1350 = 3·1303338

Q = cubic feet per hour, 78,347 = 4·8940024

These observations seem to confirm the general accuracy of the value of the coefficient as received amongst us, the small difference being virtually removed by correction for elevation.

If it is desired to know what the discharge would be under a pressure of, say, three quarters of an inch—

Then, as before, Log. 16 = 1·2041200
,, 3 = 0·4771213

1·6812413

Log. 4 = 0·6020600
,, ·556 = $\bar{1}$·7450748
,, 280 = 2·4471580 = 2·7942928

2)$\bar{2}$·8869485

$\bar{1}$·4434742

Log. 16 × 2 = 2·4082600
,, 1350 = 3·1303338

Q = cubic feet per hour, 95,951 = 4·9820480

Or to arrive at the same end by a shorter method, multiply the results obtained under a 1-inch pressure by the square root of the numerator in the fraction $\frac{3}{4}$, and divide by the square root of the denominator—thus :

$$\sqrt{4}\ (= \cdot 6324) : 110{,}794 :: \sqrt{3}\ (= \cdot 5477) = 95{,}954;$$

or briefly

$$\frac{110{,}794 \times \sqrt{3}.}{\sqrt{4}} = 95{,}954.$$

If the algebraical formula is objected to, it can very easily be resolved into a simple mathematical equation, as detailed in "Clegg." The principle is precisely the same, but the results are uniformly less, for reasons which will be obvious, and not quite so accurate as when logarithms are employed. Thus, adapting the foregoing experiment to these rules, we have in the first place to multiply the pressure by the diameter of the pipe, both in inches.

$$1 \times 16 = 16.$$

Second, add to the length of the main in yards its diameter in inches, and multiply the sum by the specific gravity of the gas. Divide the product by the results of the first term, and extract the square root of the quotient.

$$280 + 16 = 296 \times 0{\cdot}556 \div 16 \sqrt{10{\cdot}285} = 3{\cdot}163$$

Third, multiply the square of the diameter of the pipe in inches by the constant 1350, and divide by the results of the second term.

$$16 \times 16 = 256 \times 1350 \div 3{\cdot}163 = 109{,}263 \text{ cubic feet per hour.}$$

In conclusion, I have only further to add that I have gone over and wrought out the formula as given in Clegg, pp. 291–295, and have arrived at precisely similar results. The coefficient 1350 in the formula is correct so far as I can judge. Any modern experiments, therefore, which seem to require a modification of coefficients to tally with the results of experiment is probably due to inaccuracies in some of the data. With the exception of two slight, but probably misleading errors in Clegg (one in equation V., tenth line from bottom, p. 293, where we find $C - \pi d$ instead of $C = \pi d$, which being corrected, we obtain $(\frac{1}{8} g) = \frac{1}{64} 38 = {\cdot}0156$; the other is in "Practical Rules," third line from top, p. 295, where we find a small "s" substituted for a capital S, which is improper, ·07688 = weight of a cubic foot of the gas = S) I venture to express as my belief, that the article on "The Flow of Gas through Pipes," as detailed in his treatise, is the most valuable elucidation of the subject that has yet appeared, and a safe and reliable guide in the hands of the gas engineer.

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„ J. H. Robinson	Leamington	1	1	0
„ W. L. Robinson	Coventry	1	1	0
„ C. R. Robinson	Coventry	1	1	0
„ G. A. Robinson	Leicester	1	1	0
„ C. S. Robinson	Leicester	1	1	0
„ F. Bower	North Brierley	0	10	6
„ M. J. Parsons	Carnarvon	0	10	6
„ H. G. Crowe	Wellington	0	10	6
„ W. A. Padfield	Exeter	1	1	0
„ Jas. Meiklejohn	Portadown	0	10	6
„ R. Morton	London	0	10	6
„ W. Romans	London	1	0	0
„ A. F. Phillips	St. Albans	1	1	0
„ T. Doughty	Margate	0	10	6
„ J. R. Smith	Padiham	0	10	6
	Carried forward	£106	9	6

	Brought forward	£106	9	6
Mr. T. C. Crossley	Guernsey	0	10	6
„ J. Braddock, jun.	Oldham	0	10	6
„ Jas. Eadington	Blyth	0	10	6
„ D. Clarke	Glossop	0	10	6
„ W. White	Abersychan	0	10	6
„ R. Sheppard	Horsham	0	10	6
„ T. Hersey	London	1	1	0
„ T. H. Daniel	Congleton	0	10	6
„ T. Tallentire	Lisburn	0	10	6
„ T. Mossman	West Hartlepool	0	10	6
„ Geo. Cutler	Whitehaven	0	10	6
„ E. Lord	Whitworth	0	10	6
„ J. Eunson, jun.	Northampton	1	1	0
„ D. F. Goddard	Ipswich	0	10	6
„ D. Barclay	Tottenham	0	10	6
„ G. R. Hislop	Paisley	0	10	6
„ S. R. Ogden	Leeds	0	10	6
„ I. A. Crookenden	London	0	10	6
„ R. King	London	1	1	0
„ J. Clark	London	1	1	0
„ Hy. Clark	London	1	1	0
„ J. Church	London	1	1	0
„ C. Hunt	London	0	10	6
„ P. J. Wates	Greenwich	1	1	0
„ A. Williams	London	1	1	0
„ J. Dunning	Middlesborough	1	1	0
„ F. Williams	London	1	1	0
„ S. P. Leather	Burnley	1	1	0
„ J. Somerville	Dublin	1	1	0
„ A. H. Wood	Hastings	1	1	0
„ R. O. Paterson	Cheltenham	1	1	0
„ Henry Newall	Manchester	1	1	0
„ J. Aird, jun.	London	0	10	6
„ W. Shimeld	Dundalk	0	10	6
„ F. Philpots	Darsley	0	10	6
„ W. R. Hammond	Deal	0	10	6
„ James Edmund	Newtown	0	10	6
„ E. Smith	Droitwich	0	10	6
„ W. H. Chambers	Lowestoft	0	10	6
„ R. Iddon	Southport	0	10	6
„ W. Ambler	Saltaire	0	10	6
„ W. H. Willis	Yarmouth	0	10	6
„ F. M. Harris	Falmouth	0	10	6
„ Joseph Manwaring	London	0	10	6
„ James Braddock	Droylsden	0	10	6
„ J. Phelps	Marlborough	0	10	6
„ W. Box	Crayford	0	10	6
„ R. J. Fennesey	London	0	10	6
„ G. Smedley	Buxton	0	10	6
„ W. Philps	Dorking	0	10	6
„ W. C. Watson	Kingston-on-Thames	1	1	0
„ W. C. Holmes	Huddersfield	1	1	0
„ T. Trewhitt	West Hartlepool	1	0	0
„ J. Marsland	Enniskillen	0	10	6
„ W. Stiven	Inverness	0	10	6
„ G. Edson	Otley	0	10	6
„ W. R. Cooper	Banbury	0	10	6
„ R. Dempster	Elland	0	10	6
„ J. H. Cornish	Bridgwater	0	10	6
„ J. Wilson	Abingdon	0	10	6
„ J. West	Maidstone	0	10	6
„ T. Anderson	Bath	0	10	6
	Carried forward	£148	8	6

	Brought forward	£148	8	6
Mr. C. Hawksley	London	1	1	0
„ G. Garnett	Ryde	1	1	0
„ G. J. Parkinson	Birmingham	1	1	0
„ J. Hislop	Ayr	0	10	6
„ G. Helps	Bath	0	10	6
„ M. H. Loam	Nottingham	0	10	6
„ G. B. Irons	Gosport	0	10	6
„ E. Church	Huntingdon	0	10	6
„ J. Hodgson	Ulverston	0	10	6
„ W. Wood	Cambridge	0	10	6
„ Robt. Fish	Hornsey	0	10	6
„ J. Mudie	Burton-on-Trent	0	10	6
„ T. W. R. White	Sherborne	0	10	6
„ Jas. Harris	Ross	1	1	0
„ J. G. Dear	Baldock	0	10	6
„ H. T. Pierson	London	1	1	0
„ T. N. Kirkham	London	2	2	0
„ T. Forrest	Walker	0	10	6
„ G. D. Malam	Halifax	1	0	0
„ J. A. Currie	Waltham Cross	0	10	6
„ Jas. Hunter	Woolwich	1	1	0
„ J. Murray	Graingerville	0	10	6
„ G. W. Stevenson	London	1	1	0
„ J. W. O'Neill	London	1	1	0
„ W. T. Walker	London	1	1	0
„ J. A. Cowen	Blaydon	0	10	6
„ T. H. Methven	Bury St. Edmunds	1	1	0
„ J. Young	Hull	1	1	0
„ W. Daniel	Dublin	0	10	6
„ T. Dand	Exeter	0	10	6
„ M. Ohren	Lower Sydenham	0	10	6
„ J. Ohren	Rio de Janeiro	0	10	6
„ Jas. Watson	Lower Sydenham	0	10	6
„ S. Cutler	Millwall	1	1	0
„ Geo. Payne	Millwall	1	1	0
„ T. Smith	Wigan	1	1	0
„ G. Lowe	Bridport	0	10	6
„ J. Booth, jun.	Middlesborough	0	10	6
„ W. Moor	Fence Houses	0	10	6
„ W. W. Hutchinson	Barnsley	0	10	6
„ W. J. Mortis	Eltham	0	10	6
„ W. Hildreth	Darlington	0	10	6
„ M. Martin	Drogheda	0	10	6
„ Geo. Livesey	London	1	1	0
„ W. Warsop	Nottingham	0	10	6
„ W. Dore	Neath	0	10	6
„ J. W. Lawson	South Shields	0	10	6
„ G. C. Trewby	Beckton	1	1	0
„ T. Stormouth	Letterkenny	0	10	6
„ J. Wilton	Silvertown	1	1	0
„ C. R. Mead	Reigate	1	1	0
„ T. Giles	Cowes	0	10	6
„ A. F. Livesay	Chale	1	1	0
„ J. G. Livesay	Ventnor	0	10	6
„ J. Tindall	Walsall	0	10	6
„ J. Greenfield	Torquay	0	10	6
„ J. W. Baker	Limerick	1	1	0
„ E. Blanchett	Georgetown	0	10	6
„ Geo. Thorneloe	London	0	10	6
„ A. M. Murphy	Cirencester	0	10	6
„ J. S. Cranmer	Malton	1	1	0
„ F. J. Evans	London	1	1	0
	Carried forward	£194	11	6

	Brought forward	£194	11	6
Mr.	W. Blackledge	Bacup	0	10	6
„	A. Hersee	London	0	10	6
„	H. P. Stephenson	London	1	1	0
„	J. E. Clift	Redditch	1	1	0
„	A. Dougall	Kidderminster	0	10	6
„	W. C. Humphreys	New Barnet	0	10	6
„	H. Bartholomew	Lesmahago	1	1	0
„	J. B. Coulson	London	0	10	6
„	H. Lyon	Manchester	0	10	6
„	W. W. Andrews	London	1	1	0
„	E. Brickles	Santiago	0	10	6
„	J. Reid	Derby	0	10	6
„	H. Brothers	London	0	10	6
„	T. Newbegging	Pernambuco	1	1	0
„	C. Woodall	London	1	1	0
„	R. W. Brett	Hertford	0	10	6
„	W. J. Fiddes	Bristol	1	1	0
„	H. M'Pherson	Newcastle-on-Tyne	0	10	6
„	G. B. Muriel	Smyrna	1	1	0
„	H. Veevers	Bolton	1	1	0
„	W. T. Carpenter	Sheerness	1	1	0
„	G. Berry	Ashford	0	10	6
„	T. T. Markham	Hull	0	10	6
„	A. Penny	London	2	2	0
„	J. Burgess	Huddersfield	0	10	6
„	Jas. Hislop	Glasgow	1	1	0
„	A. H. Still	Cork	1	0	0
„	J. Cockcroft	Littleborough	0	10	6
„	G. R. Mellor	London	0	10	6
„	J. T. B. Porter	Lincoln	0	10	6
„	J. Stevenson	Dublin	1	1	0
„	W. H. Smith	Seaham Harbour	0	10	6
„	A. Barton	West Cowes	1	1	0
„	E. H. Harris	Wallasey	0	10	6
„	J. R. Macfarlane	Manchester	1	1	0
„	T. Travers	Cork	0	10	6
„	W. Longworth	Dukinfield	0	10	6
„	F. J. Stevens	London	1	1	0
„	W. Midhurst, jun.	Folkestone	0	10	6
„	W. Osmond	Dorchester	0	10	6
„	W. Prescott	Prescot	0	10	6
„	T. Andrews	Swansea	1	1	0
„	J. Davies	Kidsgrove	1	1	0
„	W. Moor	Hetton	0	10	6
„	H. Willey	Exeter	0	10	6
„	Hy. Green	Preston	0	10	6
„	J. Arnott	Leeds	1	1	0
„	J. T. Hall	Prescot	1	1	0
„	J. Stelfox, jun.	Belfast	1	1	0
„	E. Ozanne	Guernsey	0	10	6
„	H. T. Everest	London	0	10	6
„	J. Hegarty	Colombo	1	3	0
„	J. Brown	Dawlish	1	11	6
„	E. Price	Hampton Wick	0	10	6
„	R. Douglas	Waltham Cross	1	0	0
„	Jas. Goodwin	Rotherham	1	1	0
„	W. Bates	Worksop	0	10	6
„	H. F. Wells	Tredegar	0	10	6
„	W. Foulis	Glasgow	1	1	0
„	C. Kitto	Tonbridge	1	1	0
„	H. Bowen	Cardiff	1	1	0
„	J. Rowan	Colchester	0	10	6
	Carried forward	£243	18	6

	Brought forward	£243	18	6
Mr. R. P. Spice	London	1	1	0
„ E. Baker	Reading	0	10	6
„ T. Melling	Rainhill	1	1	0
„ J. W. Pollard	London	1	1	0
„ J. M. Darwin	Longton	0	10	6
„ W. Brown	Manchester	1	1	0
„ R. Harris	London	2	2	0
„ R. Church	Chichester	1	1	0
„ W. B. Emmerson	Darlington	0	10	6
„ C. Horsley	London	0	10	6
„ A. Brown	Woodford	1	1	0
„ F. Leslie	Moscow	1	1	0
„ J. Douglas	Portsea	2	2	0
„ E. Tidman	Middlesborough	1	1	0
„ A. C. Fraser	New Barnet	0	10	6
„ I. Kelsall	Ashton-under-Lyne	1	1	0
„ E. Genever	Dunedin	1	1	0
„ J. M'Millan	Stoke-on-Trent	0	10	6
„ W. Wright	Lewes	0	10	6
„ D. Laidlaw	Glasgow	5	0	0
		£267	6	0

SALE OF REPORTS.

Sale of reports	£16	11	1

ENTRANCE FEES.

Mr. D. B. Peebles	Edinburgh	£5	0	0
„ G. Robertson	London	5	0	0
„ Joseph Aird	Great Bridge	5	0	0
„ A. M'Dougall, jun.	Manchester	5	0	0
„ J. T. M'Dougall	London	5	0	0
„ J. Braddock, jun.	Oldham	5	0	0
„ J. Manwaring	London	5	0	0
„ W. W. Andrews	London	5	0	0
„ H. Willey	Exeter	5	0	0
		£45	0	0

BRITISH ASSOCIATION OF GAS MANAGERS.

BALANCE-SHEET, APRIL 30, 1873.

Dr.

April 30, 1872.	£	s.	d.
To Balance brought forward	301	6	5
April 30, 1873.			
To Annual Subscriptions	267	6	0
„ Donation from T. Hawksley, Esq.	5	5	0
„ Sale of Reports	16	11	1
„ Entrance Fees from Extraordinary Members	45	0	0
„ Dividends	2	18	10
„ Interest allowed by Treasurer	9	7	3
	£647	14	7

Cr.

April 30, 1873.		£	s.	d.
By Printing, Stationery, and Postages.		50	4	9
„ Expenses of Meeting in London		6	5	0
„ Expenses of Excursion		20	0	6
„ Dr. Odling's Fee and Expenses		12	12	0
„ Printing, Lithographing, Binding Reports, and Advertising		109	15	3
„ Carriage of Parcels and Sundry Expenses		7	6	6
„ Amount Voted to Hon. Secretary		50	0	0
„ „ Invested in Shares	£64 5 0			
„ „ In Treasurer's Hands	327 5 7			
		391	10	7
		£647	14	7

Examined and found correct,

May 10th, 1873.

(Signed) SAMUEL P. LEATHER, ALFRED HERSEE, } *Auditors.*

BRITISH

Association of Gas Managers.

RULES AND REGULATIONS

AND

LIST OF MEMBERS.

JUNE, 1873.

PUBLISHED FOR THE ASSOCIATION BY

W. H. BENNETT, *Secretary*,

42, PARLIAMENT STREET, WESTMINSTER.

LONDON:
CLAYTON AND CO., TEMPLE PRINTING WORKS,
BOUVERIE STREET, WHITEFRIARS, E.C.

OFFICE-BEARERS.—1873-74.

President.

GEORGE T. LIVESEY, Memb. Inst. C.E., South Metropolitan Gas-Works, Old Kent Road, London, S.E.

Vice-Presidents.

THOMAS NESHAM KIRKHAM, Imperial Gas Company's Works, Fulham, London, S.W.
JAMES PATERSON, Gas-Works, Warrington, Lancashire.
JOSEPH WOOD, Gas-Works, Bury, Lancashire.

Trustees.

EBENEZER GODDARD, Gas-Works, Ipswich.
THOMAS HAWKSLEY, 30, Great George Street, Westminster.
HENRY NEWALL, Ducie Buildings, Bank Street, Manchester.

Treasurer.

HENRY NEWALL, Ducie Buildings, Bank Street, Manchester.

Secretary.

WILLIAM H. BENNETT, 42, Parliament Street, London, S.W.

Committee.

JOHN SOMERVILLE, Alliance Gas-Works, Great Brunswick Street, Dublin.
HARRISON VEEVERS, Gas-Works, Bolton.
ALFRED UPWARD, 11, Great Queen Street, Westminster, S.W.
MATTHEW BROADHEAD, Gas-Works, Great Grimsby.
JAMES ELDRIDGE, Gas-Works, Richmond, Surrey.
JOHN HUTCHINSON, Gas-Works, Barnsley.
HENRY BOWEN, Gas-Works, Cardiff.
HENRY COCKEY, Frome Selwood, Somersetshire.
CHAS. A. CRAVEN, Gas-Works, Dewsbury, Lancashire.

Finance Committee.

GEORGE T. LIVESEY, South Metropolitan Gas-Works, Old Kent Road, London, S.E.
JABEZ CHURCH, 17B, Great George Street, Westminster, S.W.
GEORGE WILSON STEVENSON, 19, Great George Street, Westminster, S.W.

The following are, *ex officio*, also Members of the General Committee:—

ALEXANDER ANGUS CROLL, 10, Coleman Street, London, E.C.
EBENEZER GODDARD, Gas-Works, Ipswich.
THOMAS HAWKSLEY, 30, Great George Street, Westminster, S.W.
THOMAS NESHAM KIRKHAM, Imperial Gas Company's Works, Fulham, London, S.W.
GEORGE T. LIVESEY, South Metropolitan Gas-Works, Old Kent Road, London, S.E.
HENRY NEWALL, Ducie Buildings, Bank Street, Manchester.
JOSEPH WOOD, Gas-Works, Bury, Lancashire.
JABEZ CHURCH, 17B, Great George Street, Westminster, S.W.
GEORGE WILSON STEVENSON, 19, Great George Street, Westminster, S.W.
JAMES PATERSON, Gas-Works, Warrington, Lancashire.
WILLIAM H. BENNETT, 42, Parliament Street, London, S.W.

Auditors.

SAMUEL P. LEATHER, Gas-Works, Burnley.
ALFRED HERSEE, 39, Old Broad Street, London, E.C.

Office.

42, PARLIAMENT STREET, LONDON, S.W.

REGULATIONS.

SECTION I.—Object.

1.—This Association shall devote itself to the encouragement and advancement of all matters connected with Gas Engineering, Manufacture, and Finance — being established to facilitate the exchange of information and ideas among its Members.

SECTION II.—Constitution.

2.—This Association shall consist of Ordinary, Extra-Ordinary, and Honorary Members.

3.—Ordinary Members shall be either Engineers, Managers, or Secretaries of Gas-Works, who may make application for membership and be admitted.

4.—Extra-Ordinary Members shall consist of gentlemen taking an interest in matters connected with Gas-Works, and shall only be admitted upon being elected at the Annual General Meeting of the Association by a majority of two-thirds of the Members present, and will be allowed to take part in its proceedings. Besides paying the usual Annual Subscription, they will pay an Admission Fee of £5.

5.—Honorary Members shall be gentlemen who take a deep interest in matters connected with Gas Engineering, and whose scientific or practical knowledge recommends them to the Association.

SECTION III.—Management.

6.—The Management of the affairs of the Association shall be confided to a Committee, subject to the control of the General Meetings.

7.—The Officers shall consist of a President, three Vice-Presidents, Treasurer, Secretary, nine Members of Committee, and three

Members of Finance Committee, to be elected at the General Meeting, in the manner hereinafter directed. The President, Past President, or Acting President for the preceding year, Vice-Presidents, Treasurer, Trustees, Finance Committee, and Secretary shall be *ex officio* members of the General Committee. Five to be a quorum.

SECTION IV.—DUTIES OF OFFICE-BEARERS.

8.—The Office-bearers shall assume office immediately after the meeting at which they are elected. They shall hold meetings, and make arrangements for carrying out the objects of the Association.

9.—The President shall take the chair at all meetings at which he is present. He shall conduct and keep order, state and put questions, and, if necessary, ascertain the sense of the meeting upon matters before them. He may sum up, at the termination of discussions, the opinions given, and declare what appears to be the object or intention of the speaker, to which he may add his own opinion; and he shall carry into effect the regulations of the Association.

10.—The Vice-Presidents shall take part in the proceedings, and one of them shall take the chair in the absence of the President, and perform the duties enumerated in the preceding regulation. In the absence of the President and Vice-Presidents, a Chairman to be nominated from the other members of the Committee.

11.—The Secretary shall, on being appointed, receive all moneys, and pay the same to the banking account of the Association. He shall also take minutes of the proceedings at all the meetings of the Association, and enter them in proper books provided for the purpose. He shall write the correspondence, read minutes and notices at all the meetings, and also papers and communications, if the authors wish it, report discussions, and perform whatever other duties may be indicated in the regulations of the Association as appertaining to his department.

12.—The duties of the Treasurer shall be to keep in safe custody the funds of the Association.

13.—The Finance Committee shall meet periodically to receive from the Secretary a statement of accounts, and make all payments by cheque, signed by at least two members of such Committee, and countersigned by the Secretary.

SECTION V.—AUDITORS.

14.—Two Auditors, who shall be Members of the Association, but not Office-bearers, shall be chosen at each General Meeting, to examine the accounts and statements produced by the Secretary and Treasurer.

SECTION VI.—MEETINGS AND PROCEEDINGS.

15.—The Association shall hold General Meetings annually, at such time and place as shall be arranged at the previous General Meeting.

16.—At every General Meeting of the Association, the Secretary shall first read the minutes of the preceding meeting, which, on approval, shall be signed by the Chairman; the Secretary shall next read any notices or papers which may be brought before the meeting, after which new Members shall be admitted. Any business of the Association shall then be disposed of, and any communications or papers for the day be read.

17.—The Secretary shall issue notices to all Members of the Association at least fourteen days before each General Meeting, mentioning the papers to be read, and the business to be brought forward at the meeting.

18.—The Committee shall meet one hour before each meeting of the Association, and on other occasions when the President shall deem it necessary, of which notice shall be given by special circulars.

19.—All questions to be decided by any convenient system of open voting, the Chairman to have a second or casting vote when necessary. Questions of a personal nature shall be decided by ballot.

20.—Any Member, with the concurrence of the Chairman, shall have power to admit a friend to each meeting of the Association, but who shall not take any part in the discussions, unless requested to do so by the Chairman of the Meeting.

21.—All papers read at the meetings of the Association must relate to matters either directly or indirectly connected with the objects of the Association, and must be approved of by the Committee before being read.

22.—All papers, drawings, or models submitted to these meetings shall remain the property of their authors, and the Association shall afford every facility for giving this rule practical effect.

SECTION VII.—Election of New Members and Office-bearers.

23.—Every applicant for membership shall signify the same in writing to the Secretary, who shall, thereafter, submit it to the Committee, to be considered and brought by them before the next meeting of the Association for approval.

24.—Honorary Members shall be proposed to or by the Committee, and notice thereof shall be given by the Secretary at the next meeting of the Association, who shall admit them, if approved by two-thirds of the Members present.

25.—New Members to be formally introduced by the Chairman after being elected, when their names shall be entered in a roll-book of the Association, and they shall at the same time receive a copy of the regulations.

26.—If any person proposed for membership, on being balloted for, be rejected, no notice shall be taken of the proposal in the minutes.

27.—The President, Vice-Presidents, Treasurer, and Secretary shall be elected annually.

28.—The President shall in no case hold that office for a longer period than one year; and, at the expiration of such period, he shall not be re-eligible for that office for the period of three years.

29.—Three Members of the Committee shall retire annually in rotation, and be ineligible for re-election during the following year.

30.—The Committee shall, previous to the Annual Meeting in each year, prepare a list of Members whom they nominate as suitable for the offices of President, Vice-Presidents, Treasurer, and Secretary for the ensuing year. The list shall also contain the names

of twelve Members whom the Committee nominate as fitted to become Members of the Committee, and three Members to serve as a Finance Committee. A copy of such list to be forwarded to each Member of the Association before the Annual General Meeting, and each Member shall be at liberty to make a selection from the list, or to substitute the name or names of any other Member or Members for each respective office; but the number of names so selected or substituted must not in any case exceed the number to be elected to the respective offices.

SECTION VIII.—CONTRIBUTIONS OF MEMBERS TO THE ASSOCIATION.

31.—Every Ordinary and Extra-Ordinary Member shall contribute the sum of not less than 10s. 6d. annually.

32.—Honorary Members shall not be required to pay any contributions.

33.—The Annual Contributions shall be payable in advance, at or before each General Meeting.

34.—No Member whose contribution is in arrear shall be entitled to vote.

35.—Any Member retiring from the Association shall continue to be liable for annual contributions which shall have accrued due previously to the time at which he shall have given written notice of his retirement to the Secretary.

36.—Any Member may compound for his Annual Subscription by the payment in one sum of Ten Guineas. All such compositions shall be invested in the names of three Trustees, and the interest alone shall be appropriated to the current expenditure of the Association, except by special direction of the Committee.

SECTION IX.—BYE-LAWS.

37.—Any proposition for adding to or altering the regulations shall be laid before the Committee, who may bring it before the Association, if they think fit, and who shall be bound to do so on the requisition, in writing, of any five Members of the Association.

38.—Each Member of the Association shall be annually furnished by the Secretary with a copy of the Rules and Regulations, and also with a list of the names and residences of the Members.

BRITISH ASSOCIATION OF GAS MANAGERS.

LIST OF MEMBERS.

The Figures preceding the Names indicate the Date of Election.

HONORARY MEMBERS.

	NAME.	ADDRESS.
1866	Durand, Emile	72, Faubourg Montmartre, Paris
1873	Hartley, Fredk. W...	55A, Millbank Street, Westminster
1864	Hawksley, Thomas (*Trustee and Past President*)	30, Great George Street, Westminster, S.W.
1864	Letheby, Dr.	17, Sussex Place, Regent's Park, London, N.W.
1873	Macadam, Dr. Stevenson ..	Surgeon's Hall, Edinburgh
1864	Muspratt, Dr.	Duke Street, Liverpool
1868	Odling, Dr.	Oxford
1864	Rofe, John..	7, Queen Street, Lancaster
1873	Sugg, William T.	Vincent Works, Vincent Street, Westminster

(*Number of Honorary Members*, 9.)

ORDINARY MEMBERS.

1866	Allan, Geo. A.	Gas-Works, Willington Quay, near Newcastle-upon-Tyne
1873	Alsop, Samuel	Gas-Works, Pool Close, Pinxton, Alfreton
1871	Ambler, William	Gas-Works, Saltaire, Bradford
1866	Anderson, Geo.	19, Northumberland Street, Charing Cross, London, W.C.
1873	Anderson, James	Gas-Works, Ceara, Brazil
1868	Anderson, Thomas	Gas-Works, Bath
1871	Andrews, Henry Ward	10, Park Road, Haverstock Hill, London, N.W.

	Name.	Address.
1864	Andrews, Thornton	Gas-Works, Swansea
1866	Annan, John	Gas-Works, Wolverhampton
1873	Armitage, Charles	Leadenhall Street, Darlington
1867	Arnott, John	53, Belle Vue Road, Leeds
1868	Backler, Henry M'L.	11, Austin Friars, London, E.C.
1873	Bailey, George Daniel	Gas Company's Office, Lupus St., Pimlico, London, S.W.
1871	Bailey, William	Gas-Works, Camborne, Cornwall
1868	Baker, Edward	Gas-Works, Reading
1871	Baker, John William	United General Gas Company's Office, 101, George Street, Limerick
1868	Ball, John B.	Gas-Works, Loughborough
1872	Barclay, David	Gas-Works, Tottenham, N.
1870	Barratt, William	Gas Office, Accrington
1864	Bartholomew, H.	Glenorchard, Torrance of Campsie, near Glasgow
1871	Barton, Alfred	Union House, West Cowes, Isle of Wight
1867	Bates, William	Gas-Works, Worksop
1870	Beale, Frederick	Gas-Works, Beckton, North Woolwich, E.
1864	Bell, Thomas	Gas-Works. Selby
1872	Berry, George	Gas-Works, Ashford
1864	Billows, H. B.	92, Camden Street, Camden Road, London, N.W.
1868	Binks, Joshua	Gas-Works, Gomersall, near Leeds
1864	Blackburn, James	Gas-Works, Calcutta
1864	Blackburn, William	Gas-Works, Hebden Bridge
1864	Blackledge, William..	Gas-Works, Bacup
1870	Blanchett, Edward Richard ..	Gas-Works, Georgetown, British Guiana
1865	Booth, Jun., John	Gas-Works, Middlesborough
1867	Bouttell, Thos. Hy.	Gas-Works, Sleaford
1864	Bowen, Henry (*Member of Committee*)	Gas-Works, Cardiff
1870	Bower, Frederick	Gas-Works, Low Moor, North Bierley, near Bradford
1871	Box, William W.	Gas-Works, Crayford, Kent
1869	Braddock, James	Gas-Works, Droylsden Station, Manchester
1864	Braddock, Sen., Joseph	105, Windsor Road, Oldham
1864	Brandwood, D.	Gas-Works, Radcliffe, near Manchester
1872	Brett, Robert William	Gas-Works, Hertford
1867	Brickles, Edward	Gas-Works, Santiago, Chili
1872	Broadberry, William Henry ..	Gas-Works, Southend
1873	Broadhead, James	Gas-Works, Great Grimsby
1864	Broadhead, M. (*Member of Committee*)	Gas-Works, Great Grimsby

	Name.	Address.
1872	Brothers, Francis William ..	Gas-Works, Calcutta
1869	Brothers, Horatio	Gas-Works, Lupus Street, Pimlico London, S.W.
1867	Brothers, Orlando	Gas-Works, Blackburn
1871	Brown, Allan	Gas-Works, Woodford, Essex
1873	Brown, Charles..	Gas-Works, Wells, Somerset
1866	Brown, John	15, Marine Parade, Dawlish
1864	Brown, Robert	Gas-Works, Arbroath
1867	Brown, William	30, Oxford Street, Manchester
1872	Bryan, Eli..	Gas-Works, Sandbach, Cheshire
1867	Bull, Thomas	Gas-Works, Tamworth
1867	Burgess, John	Gas-Works, Huddersfield
1868	Carpenter, W. T.	Gas-Works, Sheerness
1873	Carter, Thomas..	16, Millbank Street, Westminster, London, S.W.
1864	Cathels, E. S.	New City Gas Company's Works, Montreal, Lower Canada
1871	Catlin, William Henry .. .	Alliance Gas-Works, Dublin
1865	Chambers, W. H.	Gas-Works, Lowestoft
1870	Child, Frederick	Gas-Works, Carnarvon
1864	Church, Edgar	Gas-Works, Huntingdon
1864	Church, Jabez (*Member of Finance Committee and Past President*)	17B, Great George Street, Westminster, and Gas-Works, Chelmsford
1873	Church, Jun., Jabez	17B, Great George Street, Westminster, London, S.W.
1864	Church, Robert..	Gas-Works, Chichester
1868	Clark, David	Gas-Works, Hendon, Sunderland
1869	Clark, David	Gas-Works, Brymbo
1870	Clark, Henry	Imperial Gas-Works, Haggerston, London, E.
1870	Clark, John	Imperial Gas-Works, King's Cross, London, N.
1872	Clark, Richard	Gas-Works, Devonport
1872	Clarke, David	Gas-Works, Glossop, Derbyshire
1870	Clift, John Edward	Gas-Works, Redditch
1868	Cocker, John Lees	Gas-Works, Merthyr Tydvil
1865	Cockey, Henry (*Member of Committee*)	Gas-Works, Frome
1867	Cockcroft, John	Gas-Works, Littleborough
1873	Coles, Henry A.	Gas-Works, Todmorden

	Name.	Address.
1864	Cooper, W. R.	Gas-Works, Banbury
1867	Copland, Jun., Charles	Orwell House, Beverley Road, Hull
1870	Cornish, James Hughes	Gas-Works, Bridgwater
1869	Coulson, James B.	Independent Gas Office, 236, Kingsland Road, London, E.
1866	Cox, John H.	Gas-Works, Sunderland
1872	Cranmer, Job Seymour	Gas-Works, Malton, Yorkshire
1864	Craven, Charles A. (*Member of Committee*)	Gas-Works, Dewsbury
1867	Croll, A. Angus (*Past President*)	10, Coleman Street, London, E.C.
1869	Crookenden, Isaac Adolphus ..	Phœnix Gas Office, 69, Bankside, London, [S.E.
1870	Cross, Samuel	Gas-Works, Abergavenny
1872	Crossley, Thomas C.	Gas-Works, Guernsey
1867	Crowe, Henry G.	Gas-Works, Wellington, Somerset
1872	Currie, Joseph Allan	Gas-Works, Waltham Cross, N.
1872	Cutler, George	New Gas-Works, Whitehaven
1864	Dand, Thomas	Gas-Works, Exeter
1872	Daniel, Thomas Henry	Gas-Works, Congleton
1871	Daniel, William	55, Mary Street, Dublin
1868	Darney, Robert..	Gas-Works, Faversham
1873	Darwin, Colin, Brothers	Town and Harbour Gas Company's Works, Maryport
1869	Darwin, James Malam	Gas-Works, Longton, Staffordshire
1867	Darwin, S. B.	Gas-Works, Shrewsbury
1867	Davies, John	Gas-Works, Kidsgrove
1868	Davis, William..	Gas-Works, Hereford
1867	Deakes, Josiah	Gas-Works, Worcester
1871	Dear, James Gilbert..	Gas-Works, Baldock, Herts
1864	Dempster, R.	Gas Engineer, Elland
1872	Dixon, Charles	Gas-Works, Horncastle, Lincolnshire
1867	Donaldson, John	Gas-Works, Dover
1871	Dougall, Andrew	Gas-Works, Kidderminster
1872	Dougall, Archibald	Gas-Works, Elgin
1870	Doughty, Frederick	Gas-Works, Margate
1873	Douglas, David..	Gas-Works, Chesterfield
1866	Douglas, John	Gas-Works, Portsea
1866	Douglas, Robert	Waltham Cross, N.
1868	Douglas, Thomas	51, Binfield Road, Clapham Road, London, [S.W.
1865	Dore, William	New Gas Company, Neath, South Wales
1873	Dover, John William	Gas-Works, Princes Risborough, Bucks

	Name.	Address.
1870	Drew, Thomas Allen	Gas-Works, Widnes, near Warrington
1873	Drimmie, George	Gas-Works, Holywood, Ireland
1870	Duff, William	Gas-Works, Morecambe
1864	Dunning, John	Middlesbrough
1869	Eadington, James	Gas-Works, Blyth, Northumberland
1873	Earle, Norwood	Mansion House Chambers, 12, Queen Victoria Street, London, E.C.
1873	Earnshaw, James	Gas-Works, Ashton-under-Lyne
1871	Edmond, James..	Gas-Works, Newtown, Montgomeryshire
1872	Edson, George	Gas-Works, Otley, near Leeds
1873	Edwards, Alfred James	Gas-Works, Taunton
1870	Eldridge, Henry Oswald	Gas-Works, Truro, Cornwall
1865	Eldridge, James (*Member of Committee*	Gas-Works, Richmond, Surrey
1869	Emmerson, William Barnes ..	Gas-Works, Darlington
1872	Eunson, Jun., John..	Gas-Works, Northampton
1870	Evans, Edward	Gas-Works, Shrewsbury
1870	Evans, Frederick John	Albany House, Cliftonville, Brighton
1868	Everist, Henry Thomas	High Street, Kidderminster
1872	Farrand, Frank Frederick ..	Gas-Works, Caterham Valley, Surrey
1870	Farrand, Charles	Gas-Works, Croydon
1869	Fennesey, Rodney J.	39, Old Broad Street, London, E.C.
1873	Ferguson, William	17, Pulford Street, Pimlico, London, S.W.
1865	Fiddes, Walter	Gas-Works, Bristol
1864	Fingland, John	Gas-Works, Todmorden
1870	Fish, Robert	Gas-Works, Hornsey, London, N.
1864	Fleming, W.	Gas-Works, Lancaster
1873	Folosa, P.	Gas Office, Mayaguiz, Porto Rico
1873	Forbes, John	Gas-Works, Denby Dale, near Huddersfield
1868	Ford, Geo. Mortimer	Gas Engineer, Commercial Road, Exeter
1868	Ford, William	Gas-Works, Stockton-on-Tees
1868	Forrest, Thomas	Gas-Works, Walker, near Newcastle-upon-Tyne
1868	Foster, Charles	
1870	Foulis, William	Gas Office, 42, Virginia Street, Glasgow
1864	Foxall, John	Gas-Works, Beverley
1864	Fraser, A. C.	New Barnet
1864	Frith, J. R.	Gas-Works, Runcorn

	Name.	Address.
1873	Fuller, Thomas Christopher ..	2, St. Mary's Villas, The Elms, Ramsgate
1873	Furnivall, George Steele	Gas-Works, Bradley Green, near Congleton
1869	Gardiner, Ralph	Elswick Engine-Works, Newcastle-upon-Tyne
1864	Garnett, George..	Gas-Works, Ryde, Isle of Wight
1871	Genever, E.	Gas-Works, Dunedin, New Zealand
1871	Gibb, Andrew	Gas-Works, Oswestry
1864	Giles, Thomas	Gas-Works, Cowes, Isle of Wight
1872	Gill, Joshua	Gas-Works, Dawley, Shropshire
1870	Gill, Robert	Gas-Works, Bridgnorth, Salop
1872	Goddard, D. Ford	Gas-Works, Ipswich
1864	Goddard, E. (*Trustee and Past President*)	Gas-Works, Ipswich
1872	Goldsmith, George	Gas-Works, Leicester
1872	Good, Robert	Gas-Works, Carshalton, Surrey
1870	Goodwin, James	Gas-Works, Rotherham
1869	Gore, Henry	9, Islip Street, Kentish Town, N.W.
1873	Graham, David Allan	Gas-Works, Stalybridge
1872	Green, Benjamin	Gas-Works, Mitcham, Surrey
1869	Green, Henry	Gas-Works, Preston, Lancashire
1864	Green, L. H.	Gas-Works, Dartford, Kent
1873	Greenaway, James	Gas-Works, Egham
1871	Greenfield, James	Hollacombe, Paignton, Devon
1872	Grimwood, Charles William ..	Gas-Works, Sudbury
1873	Guyatt, Thomas..	10, Coleman Street, London, E.C.
1869	Hale, John	Gas-Works, Ballymena, Ireland
1864	Hall, J. T...	Prescot, Lancashire
1873	Hamer, Thomas	Gas-Works, Chorley, Lancashire
1873	Hammond, John	Gas-Works, Bognor, Sussex
1864	Hammond, W. R.	Gas-Works, Deal
1872	Hancock, Peter..	Kinderton Street, Middlewich, Cheshire
1866	Hardick, Thos...	Gas-Works, Salisbury
1872	Hardie, William	Gas Office, Newcastle-on-Tyne
1869	Harding, George	Broad Green, near Liverpool
1873	Hardy, William	Gas-Works, Ely, Cambridgeshire
1873	Harkewitz, Herman..	Gas Office, South Bank, Yorkshire
1867	Harris, Edmund H...	Gas-Works, Wallasey, Birkenhead
1871	Harris, Frederick Mole	Gas-Works, Falmouth
1869	Harris, James	Gas-Works, Ross, Herefordshire
1870	Harris, Robert	Gas-Works, Bow Common, London, E.

	Name.	Address.
1873	Harrison, J. P.	Gas-Works, Topsham, Devonshire
1873	Hart, George	West Riding Asylum, Wakefield
1873	Hartley, Charles L.	Gas-Works, Blackburn
1870	Hastings, Peter Williams ..	16, Patshull Road, N.W.
1873	Hatch, Henry	Gas-Works, Woolton
1873	Hathaway, Henry	Gas-Works, North Shields
1866	Hawksley, Charles	30, Great George Street, Westminster, S.W.
1872	Hegarty, John	Gas-Works, Colombo, Ceylon
1868	Helps, Daniel	Gas-Works, Bath
1870	Helps, George	Gas-Works, Bath
1868	Hepworth, Joseph	Gas-Works, Carlisle
1868	Hersee, Alfred	39, Old Broad Street, London, E.C.
1872	Hersey, Thomas	Halesworth House, Massie Road, Dalston,
1873	Hickling, L.	Gas-Works, Sealdah, Calcutta [E.
1864	Hildreth, William	Colliery Offices, Darlington
1873	Hill, Henry	Gas-Works, Huyton
1872	Hislop, George R.	Gas-Works, Paisley [N.B.
1864	Hislop, James	Baronald House, Maryhill, near Glasgow,
1869	Hislop, Laurence	Gas-Works, Ayr
1865	Hodgson, James	Gas-Works, Ulverston [land
1871	Hollwey, John	Springfield, Glenageary, Kingstown, Ire-
1869	Holmes, William Cartwright ..	Iron-Works, Huddersfield
1873	Holmes, Thomas	Gas-Works, Pernambuco, Brazil
1873	Howell, E.	Gas-Works, Yeovil
1866	Hughes, Thos.	Victoria Place, Chapel Street, Slough
1870	Humphrys, William Chilton ..	Gas-Works, Albert Road, New Barnet, N.
1870	Hunt, Charles	Gas-Works, Windsor Street, Birmingham
1866	Hunter, David	2, Cambridge Villas, South Street, Greenwich, S.E.
1866	Hunter, James	Consumers' Gas Company, Woolwich, S.E.
1869	Hunter, Samuel	Gas-Works, Rochdale
1871	Hutchinson, Charles Henry ..	Gas-Works, Athens, Greece
1864	Hutchinson, John (*Member of Committee*)	Victoria Place, Chapel Street, Slough Gas-Works, Barnsley
1867	Hutchinson, Walter W.	Gas-Works, Barnsley
1871	Iddon, Robert	Gas-Works, Southport
1866	Irons, Geo. B.	Gas-Works, Gosport
1869	Jameson, J. M.	Gas-Works, Fleetwood, Lancashire
1868	Johnson, John	Chartered Gas Company, 9, Water Street, Blackfriars, London, E.C.

	Name.	Address.
1872	Jones, Charles W.	Gas-Works, Genoa
1869	Jones, E. E.	Gas-Works, Buxton, Derbyshire
1870	Jones, H. M. Layard	25, Old Broad Street, London, E.C.
1866	Jones, Hodgson..	104, Maida Vale, London, W.
1872	Jones, Walter R.	Gas-Works, Glasgow
1872	Jones, William J.	Gas-Works, Malta
1866	Jones, Robert H.	Gas-Works, Dover
1870	Jowett, James	Gas Works, Leeds
1867	Kelsall, Isaac	Midland Coal Office, 107, Piccadilly, Manchester
1873	Kemplay, Jno.	Gas-Works, Normanton
1873	Key, William	Gas-Works, Dumbarton
1871	King, Robert	8, St. Mary Axe, London, E.C.
1872	King, Robert	Stratford Road, Wolverton
1868	Kirkham, Thos. N. (*Vice-President*)	Imperial Gas Company's Works, Fulham, London, S.W.
1870	Kitt, Alfred	Chartered Gas-Works, Horseferry Road, Westminster, S.W.
1870	Kitto, Charles William	Gas-Works, Tunbridge, Kent
1872	Laing, Robert	Independent Gas-Works, 236, Kingsland Road, London, E.
1871	Lane, Denny	72, South Mall, Cork
1864	Larkum, W. J.	Gas-Works, Ripon
1870	Lawson, John Wilkinson ..	Gas Office, South Shields
1867	Lawson, William	
1873	Lawton, Robert	Gas-Works, Macclesfield
1868	Laycock, John	Gas-Works, Keighley
1864	Leather, S. P.	Gas-Works, Burnley
1866	Leslie, Frederick	Gas-Works, Moscow
1869	Little, Robert	Gas-Works, Louth, Lincolnshire
1870	Littlehales, Thomas	Gas-Works, Hamilton, Ontario, Upper Canada
1868	Livesay, Augustus F.	Chale, Isle of Wight
1865	Livesay, John G.	Gas-Works, Ventnor, Isle of Wight
1873	Livesey, Frank	South Metropolitan Gas-Works, Old Kent Road, London, S.E.
1864	Livesey, George T. (*President*).	South Metropolitan Gas-Works, Old Kent Road, London, S.E.
1866	Loam, M. H.	Gas-Works, Nottingham

	Name.	Address.
1864	Longworth, William	Gas-Works, Dukinfield
1872	Lord, Edmund	Gas-Works, Whitworth, Rochdale
1866	Lowe, James	Gas-Works, Bridport
1869	Lyne, John	Gas-Works, Wexford, Ireland
1866	Lyon, Henry	Gas-Works, Rochdale Road, Manchester.
1872	Macfarlane, J. R.	Gas-Works, Gaythorne Station, Manchester
1869	M'Millan, John	Gas-Works, Stoke-on-Trent
1869	Macnie, John	Gas-Works, Londonderry, Ireland
1873	Macpherson, Adam	Gas-Works, Kirkcaldy
1864	M'Pherson, Hugh	Gas-Works, Newcastle-upon-Tyne
1873	McCrae, B. M.	Gas-Works, Dundee
1866	Malam, Geo. Dunbar	Gas-Works, Halifax
1871	Manning, Henry	Gas-Works, Hythe, Kent
1872	Markham, Thomas T.	102, Fetter Lane, London, E.C.
1869	Marsland, John..	Gas-Works, Over Darwen, Lancashire
1864	Martin, John	Gas-Works, Ormskirk
1869	Martin, Michael	Gas-Works, Drogheda, Ireland
1871	Martin, Thomas Henry	Gas-Works, Crewe, Cheshire
1868	May, Thomas	Gas-Works, Canterbury
1872	Medhurst, Jun., William ..	Gas-Works, Folkestone
1873	Mead, A.	Gas-Works, Chelmsford, Essex
1869	Mead, Charles Roper	Wray Park, Reigate, Surrey
1871	Meiklejohn, James	Gas-Works, Portadown, Armagh, Ireland
1869	Melling, Thomas	Gas-Works, Rainhill, Lancashire
1869	Mellor, Thomas Randolph ..	Rectory House, Martin's Lane, Cannon Street, London, E.C.
1870	Methven, John..	Gas-Works, Nine Elms, London, S.W.
1864	Methven, T. H.	Gas-Works, Bury St. Edmund's
1870	Middleton, John	Gas-Works, Wandsworth, Surrey, S.W.
1873	Mildred, M.	64, Bankside, Southwark, S.E.
1867	Miles, John	Deane, near Bolton, Lancashire
1867	Miles, William	Gas-Works, Clitheroe
1870	Moir, John	Gas-Works, Newbiggin
1865	Moon, Wm. Jas.	Gas-Works, Peterborough
1869	Moor, William	Hetton Colliery, near Fence Houses
1872	Moor, William	Gas-Works, Hetton, Durham
1868	Morris, Joseph	Gas-Works, Jersey
1872	Mortis, William John	Gas-Works, Eltham, Kent, S.E.
1864	Morton, Robert	London Gas-Works, Nine Elms, London, S.W.

	Name.	Address.
1872	Mossman, Thomas	Gas-Works, West Hartlepool
1864	Mudie, John	Gas-Works, Burton-on-Trent
1872	Muriel, George	Ottoman Gas-Works, Smyrna
1864	Murphy, A. M...	Gas-Works, Cirencester
1870	Murray, John	Graingerville, Newcastle-on-Tyne
1864	Newall, Henry (*Trustee and Treasurer*)	Ducie Buildings, Bank Street, Manchester
1864	Newbigging, Thomas	Gas-Works, Pernambuco, Brazil
1872	Niven, George Henry	Gas-Works, Skelmanthorpe, near Huddersfield
1867	Niven, John	Gas-Works, Clayton, near Bradford
1870	Niven, Robert James	Gas-Works, Kettering, Northamptonshire
1870	North, William..	Gas-Works, Stourbridge
1872	Ogden, Samuel Robinson.. ..	Leeds Corporation Gas-Works, New Wortley, Leeds
1866	Ohren, John	Gas-Works, Rio de Janeiro, Brazil
1864	Ohren, Magnus (*Past Acting President*)	Crystal Palace District Gas Company, Bell Green, Lower Sydenham, S.E.
1870	Osborn, George Holmes	Gas-Works, Bromley, Kent
1866	Osmond, William	Gas-Works, Dorchester
1865	Otty, W. L.	Corporation Gas-Works, Limerick
1872	Ozanne, Ernest..	Gas-Works, Guernsey
1870	Padfield, William Albert	Gas-Office, Exe Island, Exeter
1865	Parkinson, G. J.	Gas Office, Union Street, Birmingham
1873	Parks, Thomas..	Gas-Works, Moscow
1868	Parlby, William	Gas-Works, Aylesbury
1872	Parsons, Matthew J.	Gas-Works, Carnarvon
1872	Parsons, William	Gas-Works, Atherstone
1864	Paterson, James (*Vice-President*)	Gas-Works, Warrington
1870	Paterson, Robert Ormiston ..	Gas-Works, Cheltenham
1873	Pazzani; J.	Gas-Works, Belvedere, Vienna, Austria
1868	Pearson, Thomas	
1869	Penny, Alfred	20, Abingdon Street, Westminster, S.W.
1867	Phelps, Joseph	Gas-Works, Marlborough, Wilts
1869	Phillips, Arthur Frederick ..	Gas-Works, St. Albans
1873	Phillips, E. E.	Gas-Works, High Wycombe, Bucks.
1872	Philps, Walter..	High Street, Dorking, Surrey
1871	Philpots, Frederick	Gas-Works, Dursley, Gloucestershire
1871	Pierson Henry Samuel	Matilda Cottage, Chatham Road, Wandsworth Common

	Name.	Address.
1869	Plumbe, William A...	Gas-Works, Sutton-in-Ashfield, Notts
1870	Pontifex, Samuel	Audley House, Somerset Road, New Barnet, N.
1867	Porter, J. T. B...	Gas Engineer, Lincoln
1869	Prescott, William	Gas-Works, Prescot, Lancashire
1868	Price, Edward	Gas-Works, Hampton Wick, London, S.W.
1872	Price, James	Gas-Works, Sutton, near Chester
1871	Price, Robert	Gas-Works, Llandudno, North Wales
1873	Pritchard, F.	Gas-Works, St. Helen's, Lancashire
1870	Pritchard, William	Gas-Works, St. Helen's, Lancashire
1869	Rafarel, William Claude	Gas-Works, Barnstaple, Devon
1866	Rafferty, Thomas	Out-door Superintendent, Gas Office, Albert Chambers, Albert Sq., Manchester
1871	Randall, James	Gas Office, Tottenham, N.
1868	Read, Charles	Gas-Works, Red Hill
1866	Read, John	Gas Office, Tunbridge Wells
1868	Reed, Joseph	Gas-Works, Newport, Isle of Wight
1869	Reid, John	Gas Engineer, Midland Railway, Derby
1873	Reid, Jno.	Edinburgh and Leith Gas Co.'s Office, George Street, Edinburgh
1873	Richards, William	17, Burton Road, Brixton Road, London, [S.W.
1873	Riley, James	Gas-Works, Brighouse
1865	Robinson, Chas. R.	Gas-Works, Coventry
1866	Robinson, C. S...	Gas-Works, Leicester
1866	Robinson, Geo. A.	Gas-Works, Leicester
1864	Robinson, James Henry	Gas-Works, Leamington
1864	Robinson, W. L.	Gas-Works, Coventry
1870	Rowan, John	Colchester
1864	Rowe, John	
1869	Romans, William	1, Walbrook, London, E.C.
1867	Russell, John	Gas-Works, Uxbridge
1873	Salisbury, E. H.	30, Aberdeen Pl., Maida Hill, London, W.
1870	Scott, George	Gas-Works, Tunbridge Wells
1870	Severs, George	Gas-Works, Birstall, near Leeds
1872	Sheppard, Robert	Gas-Works, Horsham, Sussex
1864	Shimeld, William	Gas-Works, Dundalk, Ireland
1864	Simpson, P.	Gas-Works, Rugby
1868	Slip, William Henry	Gas-Works, Slough, Bucks.
1866	Smedley, Geo.	Gas-Works, Buxton, Derbyshire

	Name.	Address.
1866	Smith, Edward	Gas-Works, Droitwich
1870	Smith, Henry Wall	Gas-Works, Seaham Harbour
1869	Smith, Joseph Richard	Gas-Works, Padiham
1870	Smith, Thomas	Gas-Works, Wigan
1864	Smith, Jun., William	Gas-Works, Hyde
1866	Somerville, John (*Member of Committee*)	Alliance Gas-Works, Great Brunswick Street, Dublin
1868	Spice, Robert P.	21, Parliament Street, London, S.W.
1873	Steinacher, J. E.	Gas-Works, St. John's, Porto Rico
1871	Stelfox, Jun., James	Gas-Works, Belfast
1867	Stephenson, H. P.	8, St. Mary Axe, London, E.C.
1867	Stevens, Frederick James ..	19, Southwark Bridge Road, London, S.E.
1873	Stevenson, G. E.	Gas-Works, Smichow, Bohemia
1867	Stevenson, Geo. Wilson (*Member of Finance Committee*) ..	19, Great George Street, Westminster, S.W.
1867	Stevenson, John	Gas Office, Grafton Street, Dublin
1873	Stevenson, John Stuart	114, Grafton Street, Dublin
1871	Still, Alfred H...	Gas-Works, Cork
1864	Stiven, William	Gas-Works, Inverness
1867	Stone, Thomas	Gas-Works, Weymouth
1865	Storer, John	Gas-Works, Stafford
1872	Stormouth, Thomas..	Gas-Works, Letterkenny, Ireland
1866	Stout, William	Gas-Works, Boston
1864	Strachan, John	
1870	Studholm, Shadrach..	Gas-Works, Whitehaven
1872	Swallow, David	Gas-Works, Bradford
1868	Syms, William	Gas-Works, Rochester
1864	Tadman, C.	Gas-Works, Norwich
1872	Tallentire, Thomas	Gas-Works, Lisburn, Ireland
1873	Tayler, James	Gas-Works, Fareham, Hants.
1867	Taylor, Charles..	Gas-Works, Derby
1873	Taylor, James	Gas-Works, Oldham
1873	Thomas, Alfred..	Gas-Works, Alton, Hants.
1873	Thomas, R. P.	Gas-Works, Ware, Herts.
1867	Thompson, John W...	Gas-Works, Yeadon, near Leeds
1864	Throsby, W. P...	Gas-Works, Lincoln
1872	Tidman, Edward	Gas-Works, North Ormsby, Yorkshire
1869	Tindall, John	Gas-Works, Walsall
1869	Tinney, William Upton	Gas-Works, Winchester
1872	Travers, Thomas	Gas-Works, Cork, Ireland

	Name.	Address.
1870	Trewby, George Careless.. ..	Gas-Works, Beckton, North Woolwich, E.
1867	Trewhitt, Thos.	Gas-Works, West Hartlepool
1868	Turney, Ambrose R.	
1869	Upward, Alfred (*Mem. of Com.*)	11, Great Queen Street, Westminster, S.W.
1872	Valon, William A.	Gas-Works, Ramsgate
1870	Vanheson, George B.	Gas-Works, Rochester
1869	Varley, Thomas	Gas-Works, Colne, Lancashire
1865	Veevers, Harrison (*Member of Committee*)..	Gas-Works, Bolton
1869	Venner, Bartholomew Gay ..	Gas-Works, Eton, Bucks
1864	Wadeson, James	Gas-Works, Windsor
1866	Warner, W. J.	Gas-Works, South Shields
1871	Warsop, Henry	Gas-Works, East Croft, Nottingham
1873	Waters, G. R.	The Grove, Portland
1866	Wates, Percy J.	Phœnix Gas-Works, Greenwich, S.E.
1872	Watson, James..	Crystal Palace District Gas-Works, Bell Green, Lower Sydenham, S.E.
1872	Watson, Robert..	Gas-Works, Morpeth
1872	Watson, William Clarke	Gas-Works, Kingston-on-Thames, Surrey
1869	Waugh, John	
1872	Wells, Henry F.	Gas-Works, Tredegar, Monmouthshire
1869	West, John	Gas-Works, Maidstone
1871	Whitaker, William Butler ..	Gas-Works, Belper, Derbyshire
1865	White, Edward (*Past Acting President*)	Commercial Chambers, 13, Temple Street, Birmingham
1868	White, T. W. R.	Gas-Works, Sherborne
1872	White, William	Equitable Gas-Works, Woolwich
1872	White, William..	Gas-Works, Abersychan, near Pontypool, Monmouthshire
1871	Whitehead, William Swallow.	11, Drewton Street, Bradford
1869	Wilkinson, Peter Haines.. ..	Gas Office, James Street, Harrogate
1873	Wilkinson, Thomas	Gas-Works, Drighlington
1868	Williams, Alfred	64, Bankside, London, S.E.
1864	Willis, W. H.	Gas-Works, Great Yarmouth
1871	Wilson, John	Gas and Water Company, Aldershot
1870	Wilson, William Purvis	
1871	Wilton, John	Gas-Works, Silvertown, North Woolwich, E.

	Name.	Address.
1865	Wood, Alfred H.	Gas-Works, Hastings
1864	Wood, Joseph (*Vice-President*)	Gas-Works, Bury
1866	Wood, William	Gas Office, Cambridge
1865	Woodall, Corbett	Phœnix Gas-Works, Vauxhall, London, [S.W.
1865	Woodall, Henry	Gas-Works, Longport
1872	Woodward, John	Gas-Works, Spalding, Lincolnshire
1870	Wright, Charles	Gas-Works, Saffron Walden, Essex
1864	Wright, William	Alexandra Road, Shipley, near Leeds
1868	Wright, William	Gas-Works, Lewes
1871	Wroe, John	
1864	Young, Alfred	
1869	Young, John	Gas-Works, Kingston-upon-Hull

(*Number of Ordinary Members*, 449.)

Extra-Ordinary Members.

	Name.	Address.
1872	Aird, Joseph	Wellington Tube-Works, Great Bridge, Tipton
1868	Aird, Jun., John	Belvedere Road, Lambeth, London, S.E.
1872	Andrews, William Ward ..	Gas-Meter Company's Works, 238, Kingsland Road, London, E.
1873	Ashmore, William	Hope Iron-Works, Stockton-on-Tees
1872	Braddock, Jun., Joseph	72, Windsor Road, Oldham
1868	Cowen, John A.	Blaydon-on-Tyne
1873	Cowan, William	Buccleuch Street Works, Edinburgh
1869	Cutler, Samuel	Providence Iron-Works, Millwall, Lond., E.
1870	Donaldson, A.	Buccleuch Street Works, Edinburgh
1870	Fraser, William	Inverkeithing
1865	Giles, Alfred	Rugeley
1870	Horsley, Charles	22, Wharf Road, City Road, London, N.
1871	Laidlaw, David..	Gas Engineer, Glasgow
1872	M'Dougall, James Thomas ..	10, Mark Lane, London, E.C.
1872	M'Dougall, Jun., Alexander ..	68, Port Street, Manchester
1872	Manwaring, Joseph	101, Cannon Street, London, E.C.
1871	O'Neill, John W.	Lombard Exchange, London, E.C.
1864	Owst-Atkinson, A.	Quay Chambers, Parliament Street, Hull

	Name.	Address.
1870	Payne, George	Messrs. Simpson, Payne, & Co.'s Chemical Works, Millwall, London, E.
1872	Peebles, D. Bruce	Fountainbridge Works, Edinburgh
1870	Pollard, James William	9, Mincing Lane, London, E.C.
1866	Potter, Addison	Willington Quay, near Newcastle-upon-Tyne
1870	Robertson, George	106, Leadenhall Street, London, E.C.
1859	Spence, John Berger	Earlington House, near Manchester
1870	Thorneloe, George	34, London Wall, London, E.C.
1873	Thorns, Abraham	Farnley, near Leeds
1873	Vickary, C. J.	West of England Engineering Works, Exeter
1868	Walker, William Thomas ..	Donnington, near Newport, Salop, and 8, Finsbury Circus, London, E.C.
1870	Waller, George	Phœnix Engineering Works, Holland Street, Southwark, London, S.E.
1872	Willey, Henry Frederick ..	4, Longbrook Street, Exeter
1870	Williams, Frederick..	75, Mark Lane, London, E.C.

(*Number of Extra-Ordinary Members*, 31.)

Total number of Members, 489.

LIST OF MEMBERS,

Arranged in the Alphabetical Order of the Towns they reside in.

A * prefixed to the name denotes an Honorary Member.
A + „ „ Extra-Ordinary Member.

ABERGAVENNY, Mon.	Samuel Cross, Gas-Works.
ABERSYCHAN, Mon.	William White, Gas-Works.
ACCRINGTON, Lancashire	William Barratt, Gas-Works.
ALDERSHOT, Hants	John Wilson, Gas-Works.
ALFRETON, Derbyshire	S. Alsop, Gas-Works, Pool Close, Pinxton.
ALTON, Hants.	A. Thomas, Gas-Works.
ARBROATH, Forfar, N.B.	Robert Brown, Gas-Works.
ASHFORD, Kent..	George Berry, Gas-Works.
ASHTON-UNDER-LYNE, Lancashire ..	J. Earnshaw, Gas-Works.
ATHENS, Greece	Charles Henry Hutchinson, Gas-Works.
ATHERSTONE, Warwickshire	William Parsons, Gas-Works.
AYLESBURY, Bucks.	William Parlby, Gas-Works.
AYR	Laurence Hislop, Gas-Works.
BACUP, Lancashire	William Blackledge, Gas-Works.
BALDOCK, Herts	James Gilbert Dear, Gas-Works.
BALLYMENA, Co. Antrim, Ireland ..	John Hale, Gas Works.
BANBURY, Oxon.	W. R. Cooper, Gas-Works.
BARNSLEY, Yorkshire	John Hutchinson (*Mem. of Com.*), Gas-Works.
„ „	Walter W. Hutchinson, Gas-Works.
BARNSTAPLE, Devon..	William Claude Rafarel, Gas-Works.
BATH	George Helps, Gas-Works.
„	Thomas Anderson, Gas-Works.
„	Daniel Helps, Gas-Works.
BECKTON, North Woolwich	George Careless Trewby, Gas-Works.
„	Frederick Beale, Gas-Works.
BELFAST, Co. Antrim, Ireland ..	James Stelfox, jun.

BELPER, Derbyshire..	William Butler Whitaker, Gas-Works.
BEVERLEY, Yorkshire	John Foxall, Gas-Works.
BIRMINGHAM	Edward White (*Past Acting President*), Commercial Chambers, 13, Temple Street.
,, ...	Charles Hunt, Gas-Works, Windsor Street.
,, ...	G. J. Parkinson, Gas Office, Union Street.
BIRSTALL, near Leeds	George Severs, Gas-Works.
BLACKBURN, Lancashire	Orlando Brothers, Gas-Works.
,, ,, ...	C. L. Hartley, Gas-Works.
BLAYDON-ON-TYNE	†John A. Cowen.
BLYTH, Northumberland	James Eadington, Gas-Works.
BOGNOR, Sussex	J. Hammond, Gas-Works.
BOLTON, Lancashire	Harrison Veevers (*Mem. of Com.*), Gas-Works.
BOSTON, Lincolnshire	William Stout, Gas-Works.
BRADFORD, Yorkshire	David Swallow, Gas-Works.
,, ,, ...	William Swallow Whitehead, 11, Drewton Street.
BRADLEY GREEN, Chester	G. S. Furnivall, Gas-Works.
BRIDGNORTH, Salop	Robert Gill, Gas-Works.
BRIDGWATER, Somerset	James Hughes Cornish, Gas-Works.
BRIDPORT, Dorsetshire	James Lowe, Gas-Works.
BRIGHOUSE, York	J. Riley, Gas-Works.
BRIGHTON, Sussex	F. J. Evans, Albany House, Cliftonville.
BRISTOL	Walter Fiddes, Gas-Works.
BROAD GREEN, near Liverpool ..	George Harding.
BROMLEY, Kent	George Holmes Osborne, Gas-Works.
BRYMBO, Denbigh	David Clark, Gas-Works.
BURNLEY, Lancashire	S. P. Leather (*Auditor*), Gas-Works.
BURTON-ON-TRENT, Staffordshire ..	John Mudie, Gas-Works.
BURY, Lancashire	Joseph Wood (*Vice-President*), Gas-Works.
BURY ST. EDMUND'S, Suffolk	T. H. Methven, Gas-Works.
BUXTON, Derbyshire	Geo. Smedley, Gas-Works.
,, ,, ...	E. E. Jones, Gas-Works.
CALCUTTA	James Blackburn, Gas-Works.
,, ...	Francis William Brothers, Gas-Works.
,, ...	L. Hickling, Gas-Works, Sealdah.
CAMBORNE, Cornwall	William Bailey, Gas-Works.
CAMBRIDGE	William Wood, Gas Works.
CANTERBURY, Kent	Thomas May, Gas-Works.
CARDIFF, Glamorganshire	Henry Bowen, (*Mem. of Com.*), Gas-Works

CARLISLE, Cumberland	Joseph Hepworth, Gas-Works.
CARNARVON	Matthew J. Parsons, Gas-Works.
,, ...	Frederick Child, Gas-Works.
CARSHALTON, Surrey	Robert Good, Gas-Works.
CATERHAM VALLEY, Surrey	Frank Frederick Ferrand Gas-Works.
CEARA, Brazil	J. Anderson, Gas-Works.
CHALE, Isle of Wight	Augustus F. Livesay.
CHELMSFORD, Essex	A. Mead, Gas-Works.
,, ,, ...	Jabez Church (*Mem. of Finance Committee and Past President*).
CHELTENHAM, Gloucestershire ..	Robert Ormiston Paterson, Gas-Works.
CHESTERFIELD, Derbyshire	D. Douglas, Gas-Works.
CHICHESTER, Sussex	Robert Church, Gas-Works.
CHORLEY, Lancashire	Thomas Hamer, Gas-Works.
CIRENCESTER, Gloucestershire.. ..	A. M. Murphy, Gas-Works.
CLAYTON, near Bradford	John Niven, Gas-Works.
CLITHEROE, Lancashire	William Miles, Gas-Works.
COLCHESTER, Essex	John Rowan.
COLNE Lancashire	Thomas Varley, Gas-Works.
COLOMBO, Ceylon	John Hegarty, Gas-Works.
CONGLETON, Cheshire	Thomas Henry Daniel, Gas-Works.
CORK, Ireland	Denny Lane, 72, South Mall.
,, ,, ...	A. H. Still, Gas-Works.
,, ,, ...	Thomas Travers, Gas-Works.
COVENTRY, Warwickshire	Chas. R. Robinson, Gas-Works.
,, ,, ...	W. L. Robinson, Gas-Works.
COWES, Isle of Wight	Thomas Giles, Gas-Works.
CRAYFORD, Kent	William W. Box, Gas-Works.
CREWE, Cheshire	Thomas Henry Martin, Gas-Works.
CROYDON, Surrey	Charles Farrand, Gas-Works.
DEANE, near Bolton, Lancashire ..	John Miles.
DARLINGTON, Durham	William Barnes Emmerson. Gas-Works.
,, ,, ...	William Hildreth, Colliery Offices.
,, ,, ...	Charles Armitage, Leadenhall Street.
DARTFORD, Kent	L. H. Green, Gas-Works.
DAWLEY, Salop..	Joshua Gill, Gas-Works.
DAWLISH, Devon	John Brown, 15, Marine Parade.
DEAL, Kent	W. R. Hammond, Gas-Works.
DENBY DALE, near Huddersfield ..	J. Forbes, Gas-Works.
DERBY	John Reid, Gas Engineer, Midland Railway.
,, ...	Charles Taylor, Gas-Works.

DEVONPORT	Richard Clark, Gas-Works.
DEWSBURY, Yorkshire	Chas. A. Craven, (*Mem. of Com.*), Gas-Works.
DORCHESTER	William Osmond, Gas-Works.
DORKING, Surrey	Walter Philps, High Street.
DOVER, Kent	R. H. Jones, Gas-Works.
" "	John Donaldson, Gas-Works.
DRIGHLINGTON, York.	Thomas Wilkinson, Gas-Works.
DROGHEDA, Ireland	Michael Martin, Gas-Works.
DROITWICH, Worcestershire	Edward Smith, Gas-Works.
DUBLIN	John Stevenson, Gas Office, 114, Grafton St.
"	John Somerville (*Member of Committee*), Gas-Works, Great Brunswick Street.
"	William Henry Catlin, Alliance Gas-Works, Great Brunswick Street.
"	J. Stuart Stevenson, 114, Grafton Street.
"	William Daniel, 55, Mary Street.
DUKINFIELD, Cheshire	William Longworth, Gas-Works.
DUMBARTON	W. Key, Gas-Works.
DUNDALK, Co. Louth, Ireland ..	William Shimeld, Gas-Works.
DUNDEE, Forfar	B. M. McCrae, Gas-Works.
DUNEDIN, New Zealand	E. Genever, Gas-Works.
DURSLEY, Gloucestershire	Frederick Philpots, Gas-Works.
EDINBURGH	†A. Donaldson, Buccleuch Street Works.
"	*Dr. Stevenson Macadam, Surgeon's Hall.
"	†D. Bruce Peebles, Fountainbridge Works.
"	J. Reid, Edinburgh and Leith Gas Company's Office, George Street.
"	†William Cowan, Buccleuch Street Works.
EGHAM, Surrey	J. Greenaway, Gas-Works.
ELGIN, N.B.	Archibald Dougall, Gas-Works.
ELLAND, Yorkshire	R. Dempster, Gas Engineer.
ELTHAM Kent	William John Mortis, Gas-Works.
ELY, Cambridgeshire	W. Hardy, Gas-Works.
ETON, Bucks	Bartholomew Gay Venner, Gas-Works.
EXETER, Devon	Wm. Albert Padfield, Gas Office, Exe Island
" "	Thomas Dand, Gas-Works.
" "	Geo. Mortimer Ford, Commercial Road.
" "	†C. J. Vickary, West of England Engineering Works.
" "	†Henry Frederick Willey, 4, Longbrook St.

FALMOUTH, Cornwall	Frederick Mole Harris, Gas-Works.
FAREHAM, Hants.	James Tayler, Gas-Works.
FARNLEY, near Leeds, Yorkshire ..	†A. Thorns.
FAVERSHAM, Kent	Robert Darney, Gas-Works.
FENCE HOUSES, Durham	William Moor, Hetton Colliery.
FLEETWOOD, Lancashire	J. M. Jameson, Gas-Works.
FOLKESTONE, Kent	William Medhurst, jun., Gas-Works.
FROME, Somerset	Henry Cockey (*Mem. of Com.*), Gas-Works.
GENOA, Italy	Charles W. Jones, Gas-Works.
GEORGETOWN, British Guiana ..	Edward Richard Blanchett, Gas-Works.
GLASGOW	H. Bartholomew, Glenorchard, near Glasgow.
"	Wm. Foulis, Gas Office, 42, Virginia Street.
"	Walter R. Jones, Gas-Works.
"	†David Laidlaw, Gas Engineer.
GLOSSOP, Derbyshire	David Clarke, Gas-Works.
GOMERSALL, near Leeds	Joshua Binks, Gas-Works.
GOSPORT, Hants	Geo. B. Irons, Gas-Works.
GRAINGERVILLE, Newcastle-on-Tyne	John Murray.
GREAT BRIDGE, near Tipton	†Joseph Aird, Wellington Tube-Works.
GREAT GRIMSBY, Lincolnshire ..	M. Broadhead (*Mem. of Com.*), Gas-Works.
" "	J. Broadhead, Gas-Works.
GREAT YARMOUTH, Norfolk	W. H. Willis, Gas-Works.
GREENWICH, Kent	David Hunter, 2, Cambridge Villas, South Street. S.E.
" "	Percy J. Wates, Phœnix Gas-Works.
GUERNSEY	Ernest Ozanne, Gas-Works.
"	Thomas C. Crossley, Gas-Works.
HALIFAX, Yorkshire	Geo. Dunbar Malam, Gas-Works.
HAMILTON, Ontario, Upper Canada.	Thomas Littlehales, Gas-Works.
HAMPTON WICK, Middlesex	Edward Price, Gas-Works.
HARROGATE, Yorkshire	Peter Haines Wilkinson, Gas Office, James Street.
HASTINGS, Sussex	A. H. Wood, Gas-Works.
HEBDEN BRIDGE, Yorkshire	William Blackburn, Gas-Works.
HECKMONDWIKE, Yorkshire	Thomas Green, Gas-Works.
HEREFORD	William Davis, Gas-Works.
HERTFORD	Robert William Brett, Gas-Works.
HETTON, Durham	William Moor, Gas-Works.
HIGH WYCOMBE, Bucks	E. E. Phillips, Gas-Works.

HOLYWOOD, Ireland	G. Drimmie, Gas-Works.
HORNCASTLE, Lincolnshire	Charles Dixon, Gas-Works.
HORNSEY, Middlesex	Robert Fish, Gas-Works.
HORSHAM, Sussex	Robert Sheppard, Gas-Works.
HUDDERSFIELD	John Burgess, Gas-Works.
,, ...	William Cartwright Holmes, Iron-Works.
HULL, Yorkshire	Charles Copland, jun., Orwell House, Beverley Road.
,, ,, ...	†A. Owst-Atkinson, Quay Chambers, Parliament Street.
HUNTINGDON	Edgar Church, Gas-Works.
HUYTON, Lancashire	H. Hill, Gas-Works.
HYDE, Cheshire	William Smith, jun., Gas-Works.
HYTHE, Kent	Henry Manning, Gas-Works.
INVERKEITHING, Fife, N.B.	†William Fraser.
INVERNESS	William Stiven, Gas-Works.
IPSWICH, Suffolk	E. Goddard (*Trustee and Past President*), Gas-Works.
,, ,, ...	D. Ford Goddard, Gas-Works.
JERSEY	Joseph Morris, Gas-Works.
KEIGHLEY, Yorkshire	John Laycock, Gas-Works.
KETTERING, Northamptonshire ..	Robert James Niven, Gas-Works.
KIDDERMINSTER, Worcestershire ..	Andrew Dougall, Gas-Works.
,, ,, ..	Henry Thomas Everist, High Street.
KIDSGROVE, Staffordshire	John Davis, Gas-Works.
KINGSTON-UPON-HULL, Yorkshire ..	John Young, Gas-Works.
KINGSTON-UPON-THAMES, Surrey ..	William Clarke Watson, Gas-Works.
KINGSTOWN, Co. Dublin	John Hollwey, Springfield, Glenageary.
KIRKCALDY, Fife.	A. Macpherson, Gas-Works.
LANCASTER	*John Rofe, 7, Queen Street.
,, ...	W. Fleming, Gas-Works.
LEAMINGTON, Warwickshire	James Henry Robinson, Gas-Works.
LEEDS	John Arnott, 53, Belle Vue Road.
,, ...	James Jowett, Gas-Works.
,, ...	Samuel Robinson Ogden, Leeds Corporation Gas-Works, New Wortley.

LEICESTER	George A. Robinson, Gas-Works.
,, ...	C. S. Robinson, Gas-Works.
,, ...	George Goldsmith, Gas-Works.
LETTERKENNY, Co. Donegal, Ireland	Thomas Stormouth, Gas-Works.
LEWES, Sussex	William Wright, Gas-Works.
LIMERICK	John William Baker, United General Gas Company's Office, 101, George Street.
LINCOLN	J. T. B. Porter, Gas Engineer.
,, ...	W. P. Throsby, Gas-Works.
LISBURN, Co. Antrim, Ireland ..	Thomas Tallentire, Gas-Works.
LITTLEBOROUGH, Nottinghamshire ..	John Cockcroft, Gas-Works.
LIVERPOOL	*Dr. Muspratt, Duke Street.
LLANDUDNO, North Wales	Robert Price, Gas-Works.
LONDON	†Aird, jun., John, Belvedere Road, Lambeth, S.E.
,, ...	Anderson, George, 19, Northumberland Street, Strand, W.C.
,, ...	Andrews, Henry Ward, 10, Park Road, Haverstock Hill, N.W.
,, ...	†Andrews, William Ward, Gas-Meter Co.'s Works, 238, Kingsland Road, E.
,, ...	Backler, H. McL., European Gas Office, 11, Austin Friars, E.C.
,, ...	Bailey, G. Daniel, Gas Office, Lupus Street, Pimlico, S.W.
,, ...	Billows, H. B., 92, Camden Street, Camden Road, N.W.
,, ...	Brothers, Horatio, Gas-Works, Lupus Street, Pimlico, S.W.
,, ...	Carter, T., 16, Millbank Street, Westminster, S.W.
,, ...	Church, Jabez (*Mem. of Finance Com. and Past President*), 17B, Great George Street, Westminster, S.W.
,, ...	Church, J., jun., 17B, Great George Street, Westminster, S.W.
,, ...	†Cutler, Samuel, Providence Iron-Works, Millwall, E.
,, ...	Clark, Henry, Imperial Gas-Works, Haggerston, E.
,, ...	Clark, John, Imperial Gas-Works, King's Cross, N.

LONDON—*continued* .. .. Coulson, James B., Independent Gas-Company's Office, 236, Kingsland Road, E.

" .. .. Croll, Alexander Angus (*Past President*), 10, Coleman Street, E.C.

" .. .. Crookenden, Isaac Adolphus, Phœnix Gas Office, 69, Bankside, S.E.

" .. .. Douglas, Thomas, 51, Binfield Road, Clapham Road, S.W.

" .. .. Earle, Norwood, Mansion House Chambers, 12, Queen Victoria Street, E.C.

" .. .. Fennesey, Rodney J., Continental Union Gas Co.'s Office, 39, Old Broad St., E.C.

" .. .. Ferguson, W., 17, Pulford Street, Pimlico, S.W.

" .. .. Guyatt, T., 10, Coleman Street, E.C.

" .. .. Gore, H., 9, Islip Street, Kentish Town, N.W.

" .. .. Harris, Robt., Gas-Works, Bow Common, E.

" .. .. *Hartley, Frederick W., 55A, Millbank Street, Westminster.

" .. .. *Hawksley, Thomas (*Trustee and Past Pres.*), 30, Gt. George St., Westminster, S.W.

" .. .. Hawksley, Charles, 30, Gt. George Street, Westminster, S.W.

" .. .. Hastings, Peter William, 16, Patshull Road, N.W.

" .. .. Hersee, Alfred (*Auditor*), Oriental Gas Company's Office, 39, Old Broad Street, E C.

" .. .. Hersey, Thomas, Halesworth House, Massie Road, Dalston, E.

" .. .. †Horsley, Charles, 22 Wharf Road, City Road, N.

" .. .. Johnson, John, Chartered Gas Company's Office, 9, Water St., Blackfriars, E.C.

" .. .. Jones, Hodgson, 104, Maida Vale, London, W.

" .. .. Jones, H. M. Layard, 25, Old Broad St., E.C.

" .. .. King, Robert, 8, St. Mary Axe, E.C.

" .. .. Kirkham, T. N. (*Vice-President*), Imperial Gas Company's Works, Fulham, S.W.

" .. .. Kitt, Alfred, Gas-Works, Horseferry Road, Westminster, S.W.

" .. .. *Letheby, Dr., 17, Sussex Place, Regent's Park, N.W.

LONDON—*continued*	Laing, Robert, Independent Gas-Works, 236, Kingsland Road, E.
,, ...	Livesey, George T. (*President*), South Metropolitan Gas-Works, Old Kent Road, S.E.
,, ...	Livesey, F., South Metropolitan Gas-Works, Old Kent Road, S.E.
,, ...	†Manwaring, Joseph, 101, Cannon St., E.C.
,, ...	Markham, T. T., 102, Fetter Lane, E.C.
,, ...	Mellor, Thomas Randolph, Rectory House, Martin's Lane, Cannon Street, E.C.
,, ...	†McDougall, James Thomas, 10, Mark Lane, E.C.
,, ...	Methven, John, London Gas Company's Works, Nine Elms, S.W.
,, ...	Mildred, M., 64, Bankside, S.E.
,, ...	Morton, Robert, London Gas Company's Works, Nine Elms, S.W.
,, ...	†O'Neill, John W., Lombard Exchange, E.C.
,, ...	Ohren, Magnus (*Past Acting President*), Crystal Palace District Gas Co.'s Works, Bell Green, Lower Sydenham, S.E.
,, ...	†Payne, Geo., Chemical Works, Millwall, E.
,, ...	Penny, Alfred, 20, Abingdon Street, Westminster, S.W.
,, ...	Pierson, Henry Samuel, Matilda Cottage, Chatham Road, Wandsworth Common
,, ...	†Pollard, James Wm., 9, Mincing Lane, E.C.
,, ...	Richards, W., 17, Burton Road, Brixton Road, S.W.
,, ...	†Robertson, Geo., 106, Leadenhall St., E.C.
,, ...	Romans, William, 1, Walbrook, E.C.
,, ...	Salisbury, E. H., 30, Aberdeen Place, Maida Hill, W.
,, ...	Spice, R. P., 21, Parliament Street, Westminster, S.W.
,, ...	Stephenson, H. P., 8., St. Mary Axe, E.C.
,, ...	Stevens, Frederick James, 18, Southwark Bridge Road, S.E.
,, ...	Stevenson, Geo. Wilson (*Mem. of Finance Com.*), 19, Great George Street, Westminster, S.W.

LONDON—*continued*	*Sugg, Wm. T., Vincent Works, Vincent Street, Westminster, S.W.
,, ...	†Thorneloe, George, 34, London Wall, E.C.
,, ...	Upward, Alfred (*Mem. of Com.*), 11, Great Queen Street, Westminster, S.W.
,, ...	†Walker, William Thomas, 8, Finsbury Circus, E.C.
,, ...	Waller, George, Phœnix Engineering Works, Holland Street, Southwark, S.E.
,, ...	Wates, Percy J., Phœnix Gas-Works, Greenwich, S.E.
,, ...	Watson, James, Crystal Palace District Gas Co.'s Works, Bell Green, Lower Sydenham, S.E.
,, ...	Williams, Alfred, 64, Bankside, S.E.
,, ...	†Williams, Frederick, 75, Mark Lane, E.C.
,, ...	Woodall, Corbett, Phœnix Gas-Works, Bridge Foot, Vauxhall, S.W.
LONDONDERRY, Ireland	John Macnie, Gas-Works.
LONGPORT, Staffordshire	Henry Woodall, Gas-Works.
LONGTON, Staffordshire	James Malam Darwin, Gas-Works.
LOUTH, Lincolnshire	Robert Little, Gas-Works.
LOWESTOFT, Suffolk	W. H. Chambers, Gas-Works.
LOW MOOR, North Bierley, near Bradford	Frederick Bower, Gas-Works.
MACCLESFIELD, Chester	R. Lawton, Gas-Works.
MAIDSTONE, Kent	John West, Gas-Works.
MALTA	William J. Jones, Gas-Works.
MALTON, Yorkshire	Job Seymour Cranmer, Gas-Works.
MANCHESTER	Henry Newall (*Trustee and Treasurer*) Ducie Buildings, Bank Street.
,, ...	Henry Lyon, Gas-Works, Rochdale Road.
,, ...	J. R. Macfarlane, Gas-Works, Gaythorne Station.
,, ...	James Braddock, Gas-Works, Droylsden Station.
,, ...	Thomas Rafferty, Out-door Superintendent, Gas Office, Albert Buildings, Albert Square.
,, ...	William Brown, 30, Oxford Street.
,, ...	†Alexander M'Dougall, jun., 68, Port Street.
,, ...	†John Berger Spence, Earlington House, near

MANCHESTER—*continued*	Isaac Kelsall, Midland Coal Office, 107, Piccadilly.
MARGATE, Kent..	Frederick Doughty, Gas-Works.
MARYPORT, Cumberland..	G. B. Darwin, Town and Harbour Gas Company's Works.
MARLBOROUGH, Wiltshire	Joseph Phelps, Gas-Works.
MARYHILL, near Glasgow	James Hislop, Baronald House.
MAYAGUIZ, Porto Rico	P. Folosa, Gas-Works.
MERTHYR TYDVIL, Glamorganshire	John Lees Cocker, Gas-Works.
MIDDLESBOROUGH, Yorkshire	John Dunning.
,, ,, ...	John Booth, jun., Gas-Works.
MIDDLEWICH, Cheshire	Peter Hancock, Kinderton Street.
MITCHAM, Surrey	Benjamin Green, Gas-Works.
MONTREAL, Lower Canada	E. S. Cathels, New City Gas Company's Works.
MORECAMBE, Lancashire	William Duff, Gas-Works.
MORPETH, Northumberland	Robert Watson, Gas-Works.
MOSCOW, Russia	Frederick Leslie, Gas-Works.
,, ,, ...	T. Parks, Gas-Works.
NEATH, South Wales	William Dore, New Gas Company's Works.
NEW BARNET	Saml. Pontifex, Audley House, Somerset Road
,, ...	A. C. Fraser.
,, ...	William Chilton Humphrys, Gas-Works Albert Road.
NEWBIGGIN	John Moir, Gas-Works.
NEWCASTLE-UPON-TYNE	William Hardie, Gas Office.
,, ...	Ralph Gardiner, Elswick Engine-Works.
,, ...	Hugh M'Pherson, Gas-Works.
NEWPORT, Isle of Wight	Joseph Reed, Gas-Works.
NEWTOWN, Montgomeryshire	James Edmond, Gas-Works.
NORMANTON, Derby..	J. Kemplay, Gas-Works.
NORTHAMPTON	John Eunson, jun., Gas-Works.
NORTH ORMSBY, Yorkshire	Edward Tidman, Gas-Works.
NORTH SHIELDS, Northumberland..	H. Hathaway, Gas-Works.
NORWICH, Norfolk	Chandler Tadman, Gas-Works.
NOTTINGHAM	M. H. Loam, Gas-Works.
,, ...	Henry Warsop, Gas-Works, East Croft.
OLDHAM, Lancashire..	Joseph Braddock, Sen., 105, Windsor Road.
,, ,, ...	†Joseph Braddock, Jun., 72, Windsor Road.
,, ,, ...	J. Taylor, Gas-Works.

Ormskirk, Lancashire	John Martin, Gas-Works.
Oswestry, Salop	Andrew Gibb, Gas-Works.
Otley, near Leeds	George Edson, Gas-Works.
Oxford	*Dr. Wm. Odling, F.R.S.
Over Darwen, Lancashire	John Marsland, Gas-Works.
Padiham, Lancashire	Joseph Richard Smith, Gas-Works.
Paisley, Renfrewshire	George R. Hislop, Gas-Works.
Paris	*Emile Durand, 72, Faubourg Montmartre.
Pernambuco, Brazil..	Thomas Newbigging, Gas-Works.
" "	T. Holmes, Gas-Works.
Peterborough, Northamptonshire..	Wm. James Moon, Gas-Works.
Portadown, Co. Armagh	James Meiklejohn, Gas-Works.
Portland, Dorset	G. R. Waters, The Grove.
Portsea, Hants	John Douglas, Gas-Works.
Prescot, Lancashire..	James Turner Hall.
" "	William Prescott, Gas-Works.
Preston, Lancashire..	Henry Green, Gas-Works.
Princes Risborough, Bucks ..	J. W. Dover, Gas-Works.
Radcliffe, near Manchester	D. Brandwood, Gas-Works.
Rainhill, Lancashire	Thomas Melling, Gas-Works.
Ramsgate, Kent	William A. Valon, Gas-Works.
" "	T. C. Furnivall, 2, St. Mary's Villas, The Elms.
Reading	Edward Baker, Gas-Works.
Red Hill, Surrey	Charles Read, Gas-Works.
Redditch, Warwick and Worcester	John Edward Clift, Gas-Works.
Reigate, Surrey	Charles Roper Mead, Wray Park.
Richmond, Surrey	James Eldridge (*Member of Committee*), Gas-Works.
Rio de Janeiro, Brazil	John Ohren, Gas-Works.
Ripon, Yorkshire	W. J. Larkum, Gas-Works.
Rochdale, Lancashire	Samuel Hunter, Gas-Works.
Rochester, Kent	William Syms, Gas-Works.
" "	George B. Vanheson, Gas-Works.
Ross, Herefordshire	James Harris.
Rotherham, Yorkshire	James Goodwin, Gas-Works.
Rugby, Warwickshire	Peter Simpson, Gas-Works.
Rugeley, Staffordshire	†Alfred Giles.
Runcorn, Cheshire	J. R. Frith, Gas-Works.
Ryde, Isle of Wight..	George Garnett, Gas-Works.

SAFFRON WALDEN, Essex	Charles Wright, Gas-Works.
SALISBURY	Thomas Hardick, Gas-Works.
SALTAIRE, Bradford	William Ambler, Gas-Works.
SANDBACH, Cheshire..	Eli Bryan, Gas-Works.
SANTIAGO, Chili	Edward Brickles, Gas-Works.
SEAHAM HARBOUR, Durham	Henry Wall Smith, Gas-Works.
SELBY, Yorkshire	Thomas Bell, Gas-Works.
SHEERNESS, Kent	W. T. Carpenter, Gas-Works.
SHEFFIELD..	Frederick Child, Bank View, 158, Crooks Moor Road.
SHERBORNE, Dorset	T. W. R. White, Gas-Works.
SHIPLEY, near Leeds	William Wright, Alexandra Road.
SHREWSBURY, Salop	S. B. Darwin, Gas-Works.
" "	Edward Evans, Gas-Works.
SILVERTOWN, North Woolwich ..	John Wilton, Gas-Works.
SKELMANTHORPE, Yorkshire	George Henry Niven, Gas-Works.
SLEAFORD, Lincolnshire	Thos. Hy. Bouttell, Gas-Works.
SLOUGH, Bucks..	William Henry Slip, Gas-Works.
"	Thos. Hughes, Victoria Place, Chapel Street.
SMICHOW, Bohemia	G. E. Stevenson, Gas-Works.
SMYRNA, Turkey	George Muriel, Ottoman Gas-Works.
SOUTHEND, Essex	William Henry Broadberry, Gas-Works.
SOUTHPORT, Lancashire	Robert Iddon, Gas-Works.
SOUTH BANK, Yorkshire	H. Harkewitz, Gas Office.
SOUTH SHIELDS, Durham	W. J. Warner, Gas-Works.
" "	John Wilkinson Lawson, Gas Office.
SPALDING, Lincolnshire	John Woodward, Gas-Works.
STAFFORD	John Storer, Gas-Works.
STALYBRIDGE, Lancashire	D. A. Graham, Gas-Works.
ST. ALBANS, Herts	Arthur Frederick Phillips, Gas-Works.
ST. HELEN'S, Lancashire..	William Pritchard, Gas-Works.
" "	T. Pritchard, Gas-Works.
ST. JOHN'S, Porto Rico	J. E. Steinacher, Gas-Works.
STOCKTON-ON-TEES, Durham	William Ford, Gas-Works.
" "	†W. Ashmore, Hope Iron Works.
STOKE ON-TRENT, Staffordshire ..	John McMillan, Gas-Works.
STOURBRIDGE, Worcestershire.. ..	William North, Gas-Works.
SUDBURY, Suffolk	Charles William Grimwood, Gas-Works.
SUNDERLAND, Durham	John H. Cox, Gas Office.
" "	David Clark, Gas-Works, Hendon.
SUTTON IN ASHFIELD, Notts	W. A. Plumbe, Gas-Works.

SUTTON, near Chester	James Price, Gas-Works.
SWANSEA	Thornton Andrews, Gas-Works.
TAMWORTH, Staffordshire..	Thomas Bull, Gas-Works.
TAUNTON, Somerset	A. J. Edward, Gas-Works.
TODMORDEN, Lancashire	John Fingland, Gas-Works.
,, ,, ...	H. A. Coles, Gas-Works.
TONBRIDGE. Kent	Charles William Kitto, Gas-Works.
TOPSHAM, Devon	J. P. Harrison, Gas-Works.
TORQUAY, Devon	James Greenfield, Hollacombe, Paignton.
TOTTENHAM	James Randall, Gas Office. N.
,, ...	David Barclay, Gas-Works, N.
TREDEGAR, Monmouthshire	Henry F. Wells, Gas-Works.
TRURO, Cornwall	Henry Oswald Eldridge, Gas-Works.
TUNBRIDGE WELLS	John Read, Gas Office.
,, ...	Geo. Scott, Gas-Works.
ULVERSTON, Lancashire	James Hodgson, Gas-Works.
UXBRIDGE, Middlesex	John Russell, Gas-Works.
VENTNOR, Isle of Wight	John G. Livesay, Gas-Works.
VIENNA, Austria	J. Pazzani, Gas-Works, Belvedere.
WAKEFIELD, York.	George Hart, West Riding Asylum.
WALKER, near Newcastle-on-Tyne	Thomas Forrest, Gas-Works.
WALLASEY, Cheshire	Edmund H. Harris, Gas-Works.
WALSALL, Staffordshire	John Tindall, Gas-Works.
WALTHAM CROSS, Herts	Robert Douglas.
,, ,, ...	Joseph Allan Currie, Gas-Works.
WANDSWORTH, Surrey	John Middleton, Gas-Works.
WARE, Herts.	R. P. Thomas, Gas-Works.
WARRINGTON, Lancashire	Jas. Paterson (*Vice-President*), Gas-Works.
WELLINGTON, Somerset	Henry G. Crowe, Gas-Works.
WELLS, Somerset	C. Brown, Gas-Works.
WEST COWES, Isle of Wight	Alfred Barton, Union House.
WEST HARTLEPOOL, Durham	Thomas Trewhitt, Gas-Works.
,, ,, ...	Thomas Mossman, Gas-Works.
WEXFORD, Ireland	John Lyne, Gas-Works.
WEYMOUTH, Dorset	Thomas Stone, Gas-Works.
WHITEHAVEN, Cumberland	Shadrach Studholm, Gas-Works.
,, ,, ...	George Cutler, New Gas-Works.
WHITWORTH, Lancashire..	Edmund Lord, Gas-Works.
WIDNES, Lancaster	Thomas Allan Drew, Gas-Works.